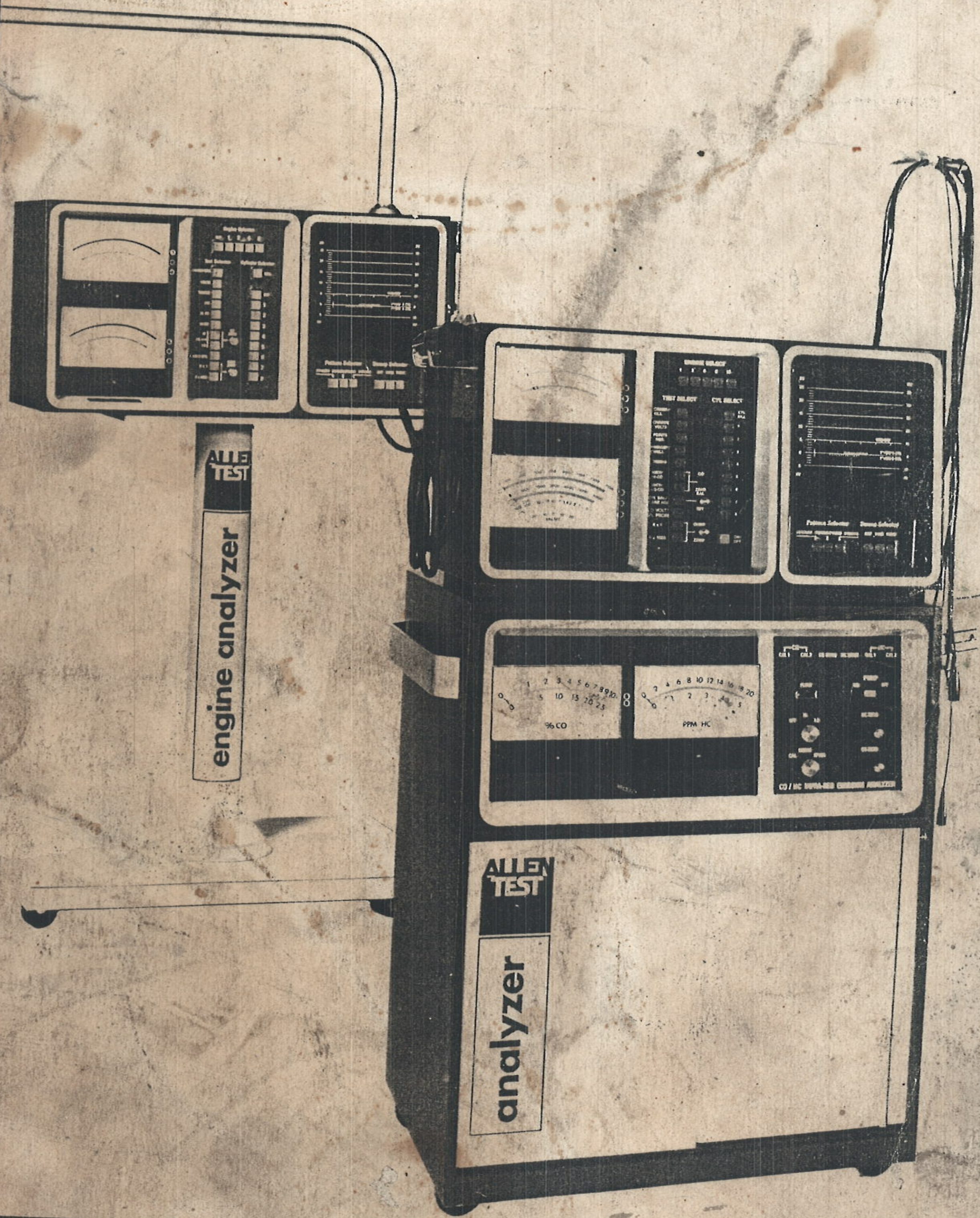
ALLEN TEST

14-000 SERIES ENGINE ANALYZER

PROGRAMMED TRAINING COURSE



ALLEN GROUP
Testproducts
Division
Kalamazoo, Michigan 49007 • Mississauga, Ontario

Price $10.50

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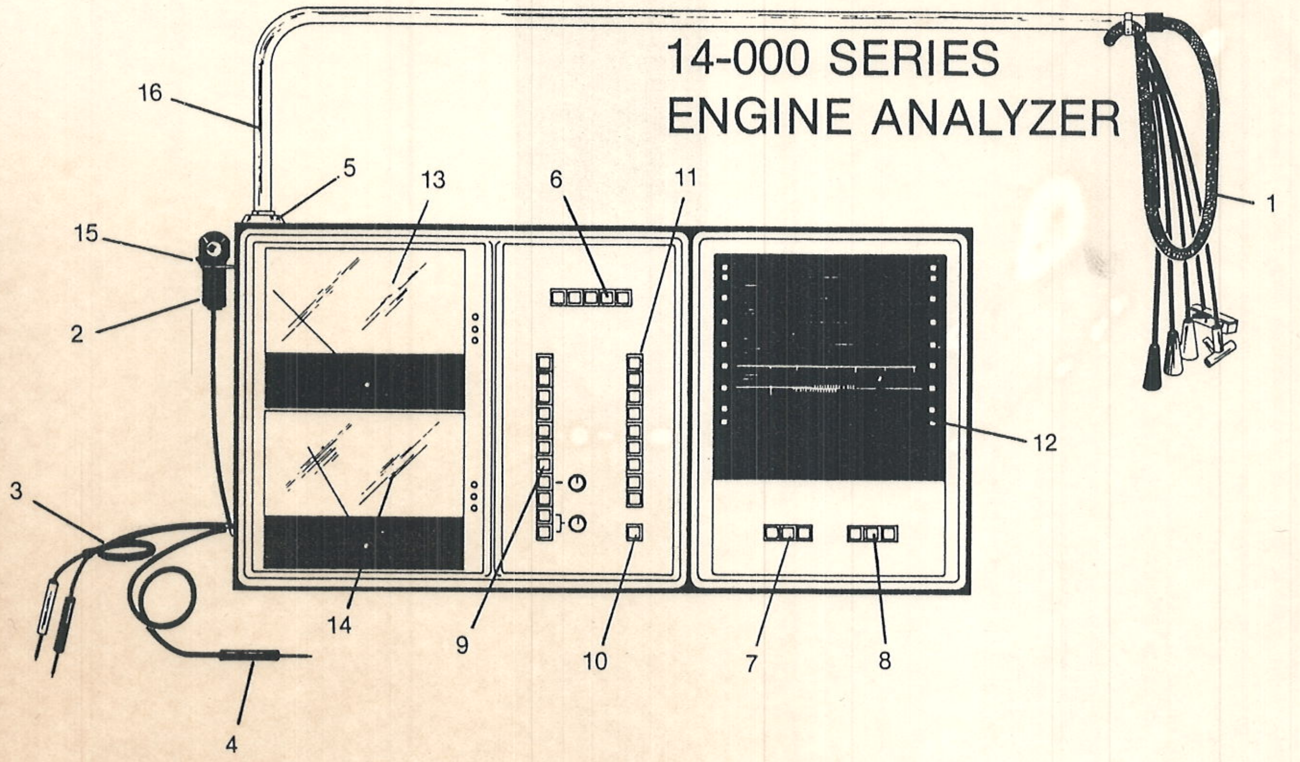

IDENTIFICATION OF CONTROLS AND METERS

1. **ENGINE TEST HARNESS**—A five (5) connection cable that has all clamp on connectors. The black insulated clip is an engine ground. The yellow insulated clip is battery volts. The green insulated clip is a primary coil connection. The "tee" clamp is a high tension wire clamp. The plug clamp is a #1 cylinder pick-up.
2. **TIMING LIGHT**—A pistol grip case that is used to direct the flash at the timing mark. A finger control trigger is used to start and stop the flash. Also, an "advance control" is located at your fingertips to provide advance measurements.
3. **OHM METER PROBES & LOW VOLTAGE PROBES**—Used for either low voltage measurements or resistance measurements.
4. **SPECIAL TEST PROBE**—Used to display any desired voltage pattern on the screen viewing area. For testing all voltage circuits from zero to 50 volts.
5. **BOOM COLLAR**—Fits over the boom as a grommet for the boom.
6. **ENGINE CYLINDER SELECT**—Select any number of engine cylinders from 1 through 16.
7. **PATTERN SELECTOR**—Selects the pattern display configuration (stacked, superimposed or parade).
8. **SWEEP SELECTOR**—Selects a normal triggered display, a special 5 millisecond display or a shifted display for the patterns on the viewing area.
9. **TEST SELECTOR**—A logical, pre-programmed test sequence selects the desired meters and electronic circuits for fast and effective analysis.
10. **ON-OFF**—Turns the unit on or off when plugged into a 110 volt AC outlet (or 220 volt AC outlet where applicable).
11. **CYLINDER SELECTOR**—Selects individual or multiple cylinders for display on the viewing area for cylinder balance testing, dwell and other testing.
12. **CRT VIEWING AREA**—Where the patterns and special voltage waveforms are viewed. The screen is calibrated for 0-25KV on the left side and 0-50 on the right side.
13. **VOLTS/PTS RES/DWELL**—A —4 volt to + 18 volt scale; —20° to + 90° timing advance scale; 0 to 90° dwell meter with a points "OK" band for point resistance. The indicator lamps to the right of the meter identify which scale to read.
14. **RPM/OHMS/BAL METER**—A 0-1500 and 0-6000 RPM meter with automatic scale switching. The ohms scale is a 0-500 or 0-500,000 scale for x1 or x1000 selection. The cylinder balance is a —25 to zero to + 25 percent scale with zero at its center.
15. **HANGER**—Side hooks for timing light storage, lead wire storage, etc.
16. **BOOM**—Keeps the engine harness from draping on the ground while vehicle testing.

REPLACEMENT PART NUMBERS

DESCRIPTION	PART NO.
A. Engine Test Harness	28922
B. Boom Assy. (Complete)	29686
C. Boom Collar	29633
D. Timing Light Assy.	29843
E. Ohm Lead	29842
F. Prod & Lead Assy.	10985
G. Procedure Pad (Diagnostic)	25597
H. Pushbutton, Blue	29610
I. Pushbutton, Red	29610-1
J. Meter Cover	20468
K. H.E.I. Adapter Plate	28253
I. Regulator Adapter	26193
J. Insulated Pliers	21339
K. Hangers, Wire & Cable	19536-3
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INTRODUCTION

The 9" Engine Analyzer is an instrument designed to allow the diagnostician to test the engine while it is operating.

This piece of test equipment follows a logical test sequence which has been designed to **do-first-things-first.**

For example, the primary/dwell test is performed prior to the timing test in order that the engine point open time has a fixed relation to the piston position prior to attempting to set the spark timing. Following this manner, an efficient and effective method of engine analysis and "tune-up" can be obtained.

Also included with your test instrument is a diagnostic inspection pad with 42 serviceable areas indicated. The inspection pad follows the same logical sequence of this manual. It will allow the diagnostician to complete an entire engine evaluation and serve as a record of test results for the customer.

The contents of this manual provide a detailed analysis of the engine's electrical, mechanical, and carburetion conditions. But, first, lets familiarize ourselves with the control panel, engine hook-up and a basic review of the primary and secondary patterns.

CONTROLS AND DISPLAYS

PATTERNS

The primary circuit consists of the battery, ignition switch, ballast resistor, primary coil and the engine points (or electronic module).

The area between one point opening and the next point opening will provide us with the normal primary pattern.

The display that we observe are voltage fluctuation that occur during this period. Each point is significant to conditions or components in the primary circuit.

FIGURE 1

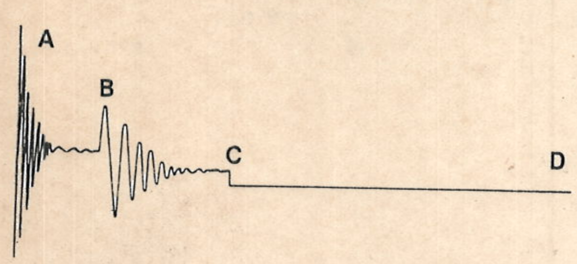


Figure 1 shows a typical primary pattern and can be viewed in various sections with each section related to specific components within the primary circuit.

- **Point A is the Point Open Time.**
  At this point the primary coil current is interrupted. As a result of the collapse of the magnetic field, a large voltage is induced in the coil (approximately 300 volts).

Primary resistance will affect the height of these first oscillations. Components like the ballast, coil and ignition switch can distort Point A.

- **The Area Between Point A & B is the Plug Firing Time.**
  This is the time the spark is occurring across the spark plug electrodes. Energy is rapidly being drawn from the **coil** at this time.

Insufficient current in the primary coil would result in a short, weak spark and cause Point B to move towards Point A.

- **The Area Between Point B & C is termed the Coil/Condenser Oscillations.**
  At Point B the spark quits firing, however, there is energy remaining in the coil at this time. It is the responsibility of the **coil** and **condenser** to dissipate what remains. If the primary circuit was weak, little energy would remain in the coil. Consequently, the number of oscillations would be reduced. Typically, there should be 5 distinct oscillations visible.

- **Point C. is the Time the Engine Points Close.**
  The closing should be quick and sharp with no distortion noticeable. Weak spring tension or excessive point contact wear is detectable at this point.

Electronic modules provide a similar condition except this point is the result of a transistor action rather than a mechanical action.

- **The Area Between Points C & D is the Dwell Time.**
  During this time current begins to flow through the primary coil once again building the magnetic field and preparing for the next plug firing. Dwell time is important to adequate coil saturation. Insufficient dwell can result in high speed misfire by keeping the current low or low energy. Excessive dwell is hard on engine points and may result in contact wear and eventual arcing.

The secondary circuit consists of the secondary coil, high tension wire, rotor, cap, spark plug wires and spark plugs. The area between one spark plug firing and the next spark plug firing will provide us with the secondary pattern.

Again, the display we observe is voltage fluctuation that occurs during this period. Each point is significant to conditions and components in the secondary circuit.

FIGURE 2

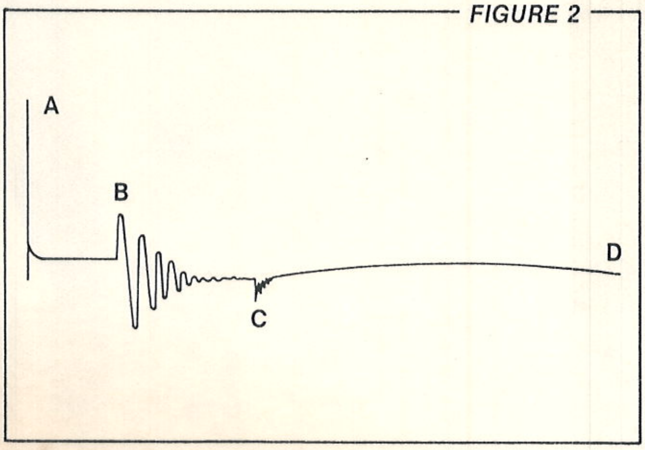


Figure 2 shows a typical secondary pattern and can be viewed in various sections.

- **Point A is the Voltage Demand of the Spark Plug to Ionize the Spark Gap.**
  When the primary field has collapsed a very high voltage is induced in the secondary coil. This voltage rises to a level sufficient to jump a spark across the plug electrodes.

Plug gap, compression, and fuel mixture are important conditions in determining how much voltage is necessary.

- **The Area Between Points A & B is the Voltage Required to Keep the Spark Going.**
  Its length is indicative of the amount of voltage or energy the coil has and the conditions existing within the combustion chamber. Spark plug wires, spark plugs, valves, fuel or anything in the combustion chamber can distort the sharpness and clarity of this line.
- **The Area Between B & C is, again, the Coil and Condenser Oscillations as Described in the Primary Pattern.**
- **Point C is where the Engine Points Close.**
  At this point the primary current is reflected in the secondary circuit. Analysis of this point can tell us a lot about the primary circuit.

A section further on in this manual has been given to analysis of this point (Section 5).

- **The Area Between Points C & D is the Coil Saturation Time or Dwell Time.**
  These conditions have already been described in the primary pattern.

  Electronic ignition systems produce very similar primary and secondary patterns. Where differences occur, the pattern will be shown in the section specific to the electronic ignition system in the last pages of this manual.

CONTROLS

The scope analyzer is a tool to aid the operator in efficient and logical diagnosis of engine problems. Understanding the controls and their functions initiate your proficiency.

1	2	4	8	16
☐	☐	☐	☐	☐

ENGINE SELECT

The engine select pushbuttons allow the operator to select any number of cylinders between 1 and 16 by selecting one or more pushbuttons so their totals add up to the desired number of engine cylinders.

EXAMPLE

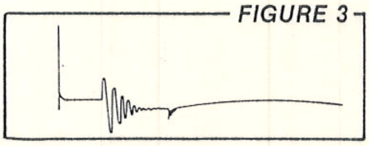
3 CYL ENGINE—SELECT 1 & 2
6 CYL ENGINE—SELECT 2 & 4
8 CYL ENGINE—SELECT 8

SWEEP SELECTOR

OFF	5MS	SHIFT
☐	☐	☐

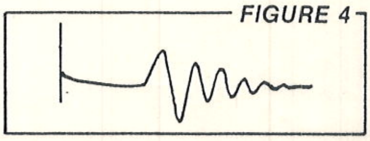
The **off** pattern select displays the sweep as shown in Figure 3.

FIGURE 3



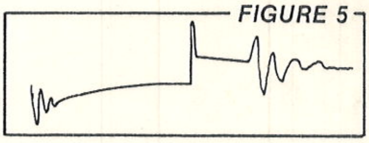
The **5Ms** pattern select displays the sweep as shown in Figure 4.

FIGURE 4



The **Shift** pattern display shows the sweep as in Figure 5.

FIGURE 5

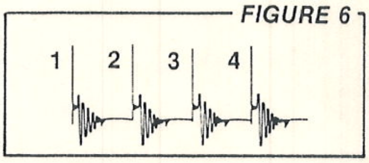


PATTERN SELECTOR

STACKED	SUPERIMPOSED	PARADE
☐	☐	☐

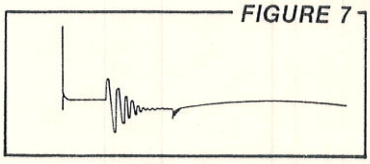
The parade pattern displays each cylinder in-a-line starting with #1 and proceeding according to the firing order.

FIGURE 6



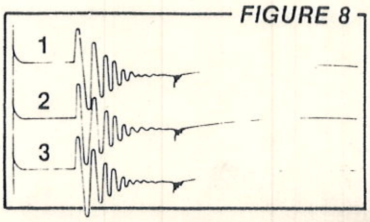
The superimposed pattern displays each cylinder on top of one another.

FIGURE 7



The stack pattern displays each cylinder above one another starting with the #1 at the top and proceeding down according to the firing order.

FIGURE 8



The cylinder short and cylinder select pushbuttons are used to select individual or multiple cylinders from the superimposed display and to "kill" the cylinder or cylinders selected. The #1 pushbutton always selects the #1 cylinder while the #2 through #8 pushbuttons select the second through eighth cylinders in the firing order.

A typical firing order may be 1, 5, 4, 2, 6, 3, 7, 8. In this case the #4 pushbutton selects the #2 cylinder.

When the CYL Short pushbutton is depressed the selected cylinders will not fire.

- ☐ **CYL KILL**
- ☐ **1**
- ☐ **2**
- ☐ **3**
- ☐ **4**
- ☐ **5**
- ☐ **6**
- ☐ **7**
- ☐ **8**

Each button must be pushed-to-select and pushed-to-release (push-push).

For a single selected cylinder display, the pattern selector must be in the **superimposed** mode and the desired cylinder pushbutton must be selected from the **cylinder selector.**

For any engine with more than 8 cylinders, select the pushbuttons 1 through 8 for the first eight cylinders, then move the **#1 pickup** to the 9th cylinder in the firing order and repeat the selection 1 through 8 for the 9th through 16th cylinder.

CRANK KILL	☐	
CHARGE VOLTS	☐	
PTS RES	☐	
PRIMARY DWELL	☐	
TIMING	☐	
50KV HI CO	☐	CO
25KV LO CO	☐	ZERO
CYL BAL CARB ADJ	☐	
2 VOLT SPEC.	☐	BAL SET
R X 1	☐	OHM
R X 1000	☐	ZERO

The test selector switch is programmed in a logical test sequence for diagnostic efficiency.

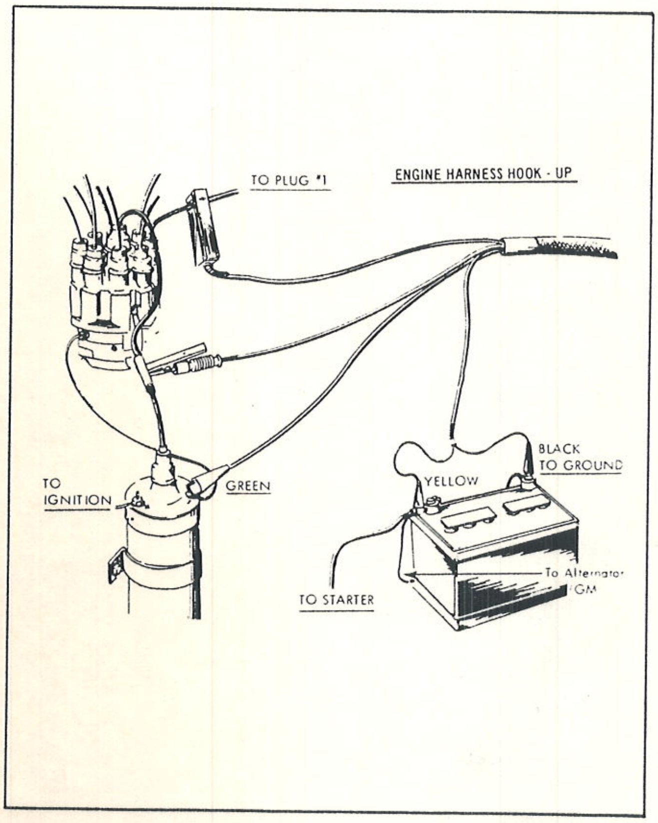
A complete diagnostic test procedure is provided in the latter sections of this manual. Each section is identified by the pushbutton used for the particular testing.

The controls to the right of the pushbuttons are to be used with their respective pushbuttons. Just follow the lines to the test selection.

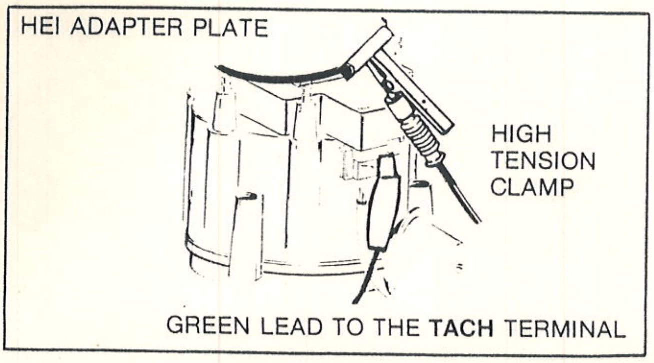
ENGINE HOOK-UP

The engine harness hook-up is a simple 5 connection procedure that senses all the necessary inputs to perform a complete diagnosis.

1. Connect the ground (black) clip to the battery negative terminal or a good engine ground.
2. Connect the volt (yellow) clip to the positive battery terminal.
3. Connect the primary (green) clip to the distributor side of the coil.
4. Connect the high tension (T clamp) to the coil wire.
5. Connect the #1 cylinder pick-up to the #1 spark plug wire.



The solid state ignition system is to be connected in the same manner as any conventional system except for the GM HEI. With this system, the ignition coil is an internal part of the distributor. The green clip is to be connected to the tach terminal of the distributor and the high tension clamp is to be connected to the HEI adapter plate.



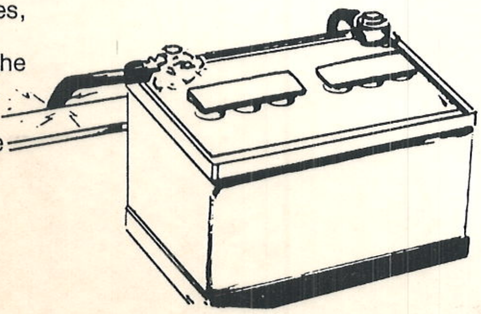
SECTION ONE

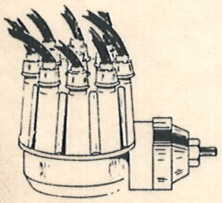
VISUAL INSPECTIONS

1.1 A piece of test equipment is a tool designed to test components for specific performance. It will assist the diagnostician in determining malfunctions and making corrections quickly and efficiently. It will discover unknown factors and verify hidden problems but . . . it does not substitute for the eyes . . .

Take a few minutes and look around before proceeding with your tests and measurements.

1.2 Inspect the battery for corroded terminals, cracked top, frayed cables, tight hold down clamps. Check the electrolyte level. Many battery problems can be found this way.

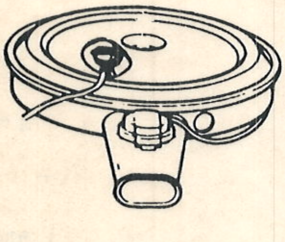




1.3 Inspect the plug wires, HT cable, for cracked or oil soaked conditions.

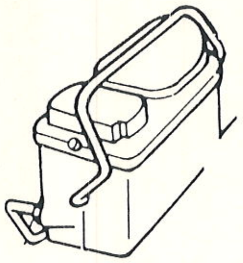
Also—how are the connections to the coil, solenoid, etc.

1.4 Inspect the air filter and check it against the light. Pay particular attention to the area where the PCV hose connects, it may provide a clue about excessive "blowby".



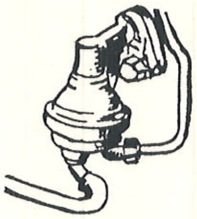
1.5 Check the oil level and inspect for cleanliness. This may provide a clue about valve action tests to be performed later.

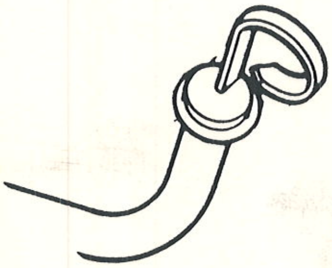
1.6 Check the belt tension and inspect for frayed, or glassy coated belts.



1.7 Check the steering and brake fluid levels. Anything which demands maintenance requires periodic inspections to assure they are kept in good working order.

1.8 Check for evidence of oil or fuel leakage from gaskets, fuel lines and carburetor.





1.9 Check the automatic transmission fluid level while the engine is running. Not only check for color or level, but smell the fluid for burned odors.

SECTION TWO

STARTING CIRCUIT

The purpose of this test is to determine whether the circuit can deliver the power necessary to start the engine.

CRANK KILL ☐ **SELECT THE CRANK/KILL PUSHBUTTON**

2.1 Initial Battery Voltage
While the battery voltage is not conclusive at this point, it is important to note the reading on the diagnostic report.

- The battery voltage should read:

6 Volt Battery— 5.7V minimum
12 Volt Battery—11.4V minimum
24 Volt Battery—22.8V minimum

2.2 Cranking Voltage & Cranking Speed
The purpose of this test is to determine battery capacity and engine speed since either of these conditions can identify hard starting problems.

Both the tachometer and voltmeter should be observed together.

- Crank engine with the ignition key for 15 seconds while observing the tachometer & voltmeter. **In this mode the engine will not start.**

Battery Capacity	9.6 Volts
Engine Speed	100 RPM

The 9.6 volts or more applies to all 12V systems and is considered the lowest acceptable limit for the battery.

100 RPM or more will depend on the size of the engine under test.

2.3 Recovery Voltage

- Immediately after cranking observe the battery recovery voltage.

A good sufficiently charged battery will recover immediately to 12 volts or more.

If the level remains below 12 volts, an indication of a shorted cell exists while, if the recovery is slow, but the battery had a initial level, an indication of a sulfated battery exists.

Initial Battery Voltage	Cranking Voltage	Cranking Speed	Recovery Voltage	Likely Problem
Good	Low	Good	Good	Starter
Good	Good	Low	Good	Batt Cables/ Starter
Low/ Good	Low	Low	Low/ Good	Battery
High	Good/ Low	Good/ Low	Slow	Sulfated Battery
Good	Low	Good/ Low	Low	Shorted Cell

2.4 Battery Cable Volt Drop Test

- If the cranking speed was low and the battery cranking voltage was good, the problem could be the battery cables.
- Place the yellow volt clip at the armature terminal of the starter or solenoid.
- Repeat the cranking test and observe the volt reading.

If the volt reading is 9 volts or more a negative battery cable is suspected.

If the volt reading is less than 9 volts a positive battery cable is suspected.

SECTION THREE

The purpose of this test is to determine if the regulator and charging circuit is functioning.

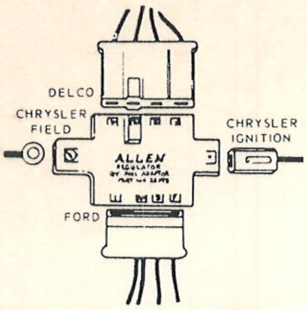
CHARGE VOLTS ☐ **SELECT THE CHARGE/VOLTS PUSHBUTTON**

- Start the engine and observe the voltmeter after it stabilizes.

The reading should be between: 13.8 Volts—15.3 Volts

If the volt reading remains low bypass the voltage regulator to determine whether the regulator or alternator is at fault.

- Turn engine OFF.
- Disconnect the regulator and place a jumper wire between the battery + terminal and the "field" terminal of the alternator or use a bypass adapter as shown to the right.



- On older model GM, AMC and Chrysler vehicles with "A" circuit generators, remove the FLD wire from the regulator and connect it to ground or ground the FLD terminal of the regulator with a jumper wire.

On older model Ford vehicles with "B" circuit generators remove the FLD wire from the regulator and connect it to the ARMATURE or BATTERY terminal of the regulator.

- Start the engine and slowly increase the RPM to reach the rated alternator our generator output . . . do not run the engine for more than 20 seconds.

- If the volt reading rises, the regulator is defective or will require resetting.

If, however, the volt reading remains low, a defective alternator is indicated.

Stop engine. Disconnect jumper wire or bypass and reconnect voltage regulator.

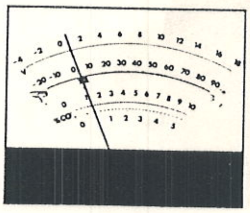
SECTION FOUR

The purpose of this test is to measure the resistance between the negative side of the coil and ground on conventional breaker point systems only.

PTS RES ☐ **SELECT THE PTS RES PUSHBUTTON**

- Allow the engine to idle and observe the point resistance scale on the lower meter.

- The meter should indicate within the "OK" band.



If the meter reads outside the OK band:

1. High resistance in the wire from the negative terminal of the coil to the distributor.
2. Poor breaker point plate ground.
3. Distributor to engine block corrosion.
4. High resistance points (contact area worn or pitted).
5. Negative battery terminal to engine block corrosion.

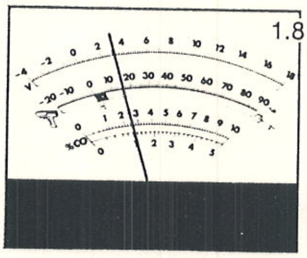
4.1 Verify the Problem.

SELECT THE LO VOLT/SPECIAL PUSHBUTTON **LO VOLT SPECIAL** ☐

- Shut off the engine.

- Use the ohmmeter leads connected as follows:
  Black lead to battery negative
  Red lead to coil negative (same point as the green clip)

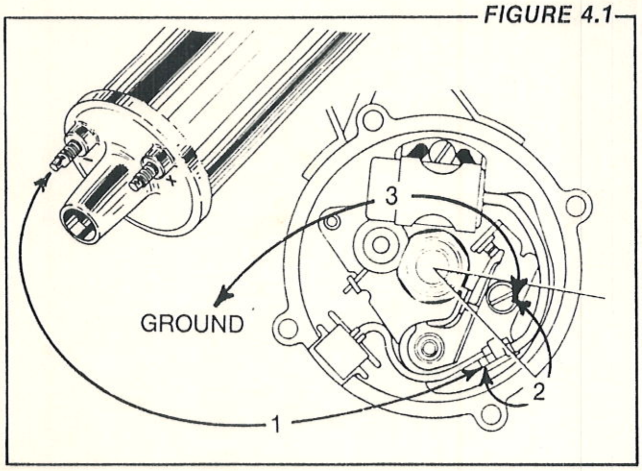
- Remove the distributor cap and bump the engine over until the points are closed.



- Leave the ignition switch "ON". The voltmeter top scale is to be read as a 0-1.8 voltmeter.

High point resistance should provide a volt reading above .3 volts. To locate the area of high resistance place jumper wires as shown in Figure 4.1.

FIGURE 4.1



1. Place a jumper from the coil to the points.
2. Place a jumper across the points.
3. Place a jumper from the breaker plate to ground.

If any one of the jumpers reduce the voltmeter reading, the problem area has been localized.

Point resistance measurements on electronic ignition systems are of no significance.

SECTION FIVE

The purpose of this test is to determine if the primary circuit is operating properly.

PRIMARY DWELL ☐ **SELECT THE PRIMARY/DWELL PUSHBUTTON**

5.1 Dwell Angle

The dwell angle is the number of degrees the distributor cam rotates while the engine points are closed.

Excessive dwell can cause point contact wear or discoloration and ultimately result in arcing points and short life.

Insufficient dwell can cause high speed misfire by not allowing enough primary coil current.

- Observe the dwell meter while the engine is running; if the reading is outside of the manufacturers specifications, readjust—

5.2 Setting the Dwell while Cranking

- Remove the distributor cap and loosen the point hold down screw.
- Crank the engine and insert a screwdriver into the adjustment slot—set the dwell meter reading to manufacturers specifications (Figure 5.1)

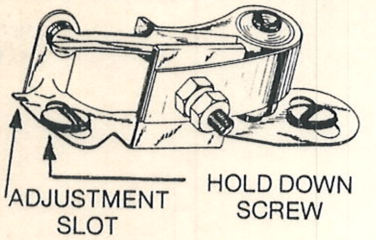
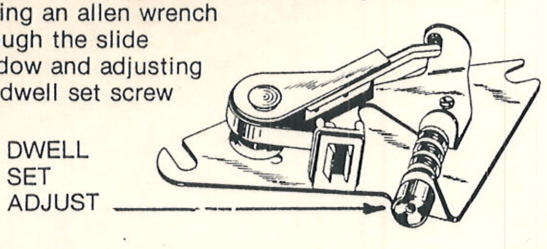


FIGURE 5.1

On some GM and AM Ignition Systems the point dwell can be adjusted while the engine idles by inserting an allen wrench through the slide window and adjusting the dwell set screw

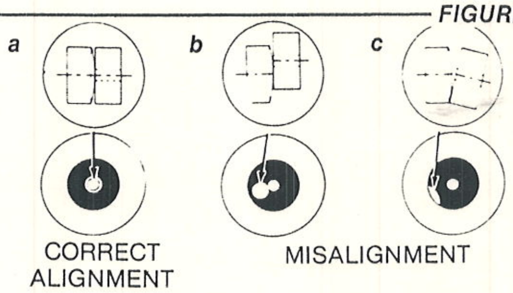


Dwell measurements on most electronic ignition systems are of no significance since the electronic modules control the dwell.

However, for the International Harvester BID System, a dwell specification is required. The dwell is to be set by changing the air gap between the sensor coil and the trigger wheel. (Refer to the section on AM/IH BID Electronic Ignition Systems in this manual).

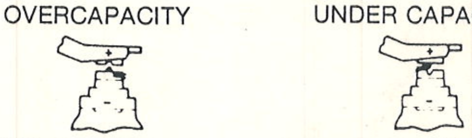
Care should be taken to assure the point contact alignment is maintained and that the point contact area doesn't become contaminated with oil or grease. Also, inspect the points for pitting. It may give you a clue about the condenser.

FIGURE 5.2



1. ***Figure 5.2a*** shows the contact points with their centers touching.
2. ***Figure 5.2b*** shows the centers of the contact points mismatched.
3. ***Figure 5.2c*** shows the faces of the contact points out of line.

FIGURE 5.3



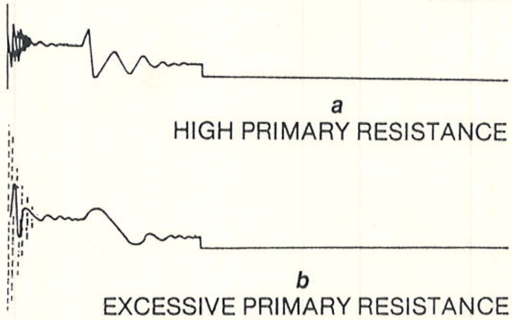
CONDENSER TOO LARGE
Pitting occurs in the moving contact

CONDENSER TOO SMALL
Pitting occurs in the stationary contact

5.2 Primary Resistance

The height of the initial primary oscillation is dependent on the amount of primary coil current. Insufficient height may indicate excessive resistance in the ignition switch, ballast resistor, coil or contact point circuit.

FIGURE 5.4


a
HIGH PRIMARY RESISTANCE

b
EXCESSIVE PRIMARY RESISTANCE WITH OCCASIONAL MISFIRE

Figure 5.4a shows the primary "superimposed" pattern with lower than normal first oscillations.

Figure 5.4b shows excessive primary resistance, a condition that can be created by an excessively high resistance ballast or coil or a "partially shorted" condenser. Note also an occasional misfire indicated by the dotted line (a condition that will likely result from excessive primary resistance).

Verify:

- Select the Charge/Volts pushbutton
- Connect the yellow volt clip to the positive side of the coil.

The voltmeter should read between:

7 volts—9 volts

Excessive voltage indicates—coil
Insufficient voltage indicates—ballast or ignition switch
Voltage OK indicates—condenser

5.3 Coil/Condenser Oscillations

Because the coil and condenser function as a matched set, a defect in either component will reduce or kill the oscillations in either the primary or secondary circuit.

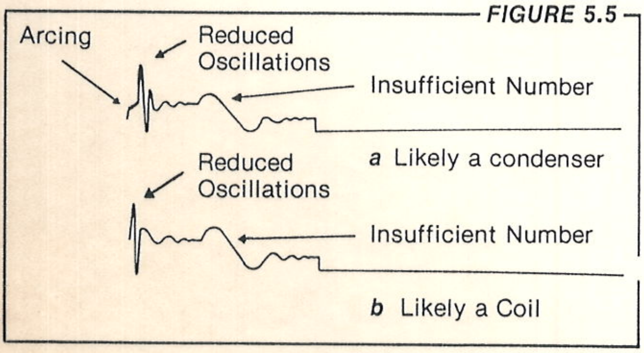


FIGURE 5.5

There is very little difference between a defective coil and a defective condenser.

Figure 5.5a shows the possible condition existing with a defective condenser. Since the condenser has the function of reducing point arcing, generally this condition will appear.

Figure 5.5b does not display the arcing condition, therefore it strongly suggests a coil problem.

5.4 Dwell Variation

Variations in dwell time can be seen on the screen viewing area or determined by selecting the individual cylinders and reading the dwell for that particular cylinder.

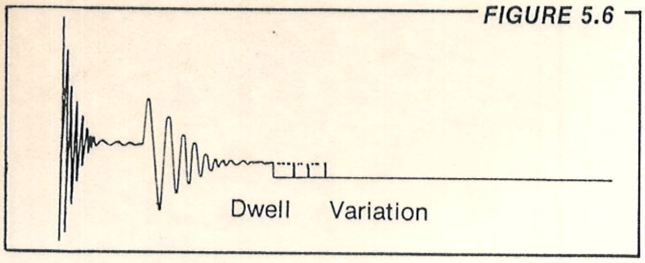


FIGURE 5.6

Excessive variation (more than 5°) is unacceptable, (Figure 5.6).

These conditions can be a result of:

1. Uneven cam lobes
2. Bent distributor shaft
3. Worn bushings in the distributor

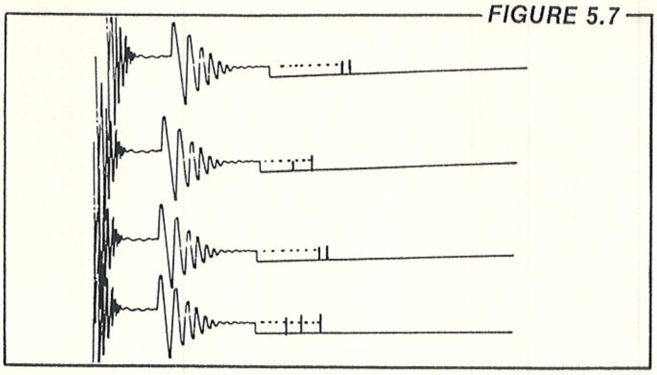


FIGURE 5.7

Figure 5.7 shows the primary pattern in the stacked display. Also notice the erratic display (symbolized by the dotted line) in the point close area.

- Observe the point close condition while momentarily accelerating the engine with the throttle.
- If the pattern point close marks stabilize while the engine RPM increases, a timing chain problem may be indicated.

Before attempting to replace the timing chain further verification is recommended. First check to see if the distributor is locked down tight to the engine block.

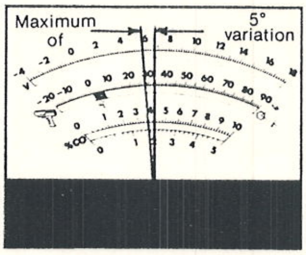
VERIFY:

1. Stop the engine and bump the starter until the timing mark appears—Mark the damper pulley with chalk at the TDC mark on the indicator.
2. Remove the distributor cap and watch the rotor while turning the crankshaft in the opposite direction.
3. When the rotor starts to turn, mark the pulley again at the TDC indicator.

The difference between the first and second mark should not exceed 4°.

5.5 Alternate Method of Dwell Variation

- With the engine running at idle, observe the dwell meter.
- Select the #1 cylinder with the individual cylinder pushbuttons and note the dwell reading.



- Proceed with #2 through #8 (or the last cylinder). Note the dwell for each cylinder.

A maximum variation of 5° between the lowest and highest dwell reading is acceptable.

5.6 Arcing Points

For the coil to produce a sufficiently high voltage in the secondary, the primary current must be interrupted sharply. When the engine points begin to open and current continues to flow due to arcing (jumping the gap) much of the potential energy in the secondary coil is lost.

- Select the shift pushbutton in the sweep selector and the superimposed pushbutton in the pattern selector
- Observe the screen viewing area as shown in Figure 5.8 for evidence of point arcing.

SHIFT
☐

SUPERIMPOSED
☐

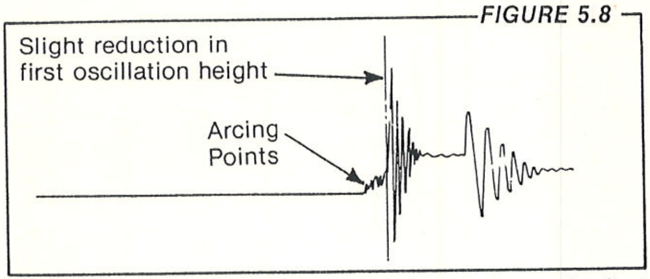


FIGURE 5.8

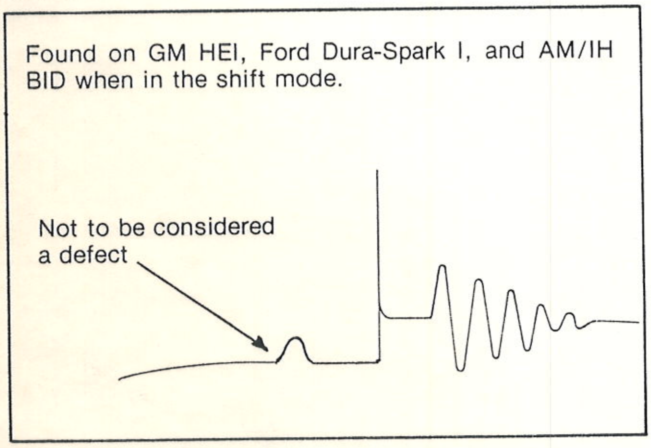
Note any intermittent condition occuring prior to the first primary oscillation and a slight reduction in the height of the first oscillation.

Typically this is an indication of badly pitted points or possibly a defective condenser.

Once this condition results, both the points and condenser should be replaced.

With electronic ignition systems the first primary oscillation will generally be a clean break.

However, in the shifted mode, some high energy systems such as GM HEI, Ford Dura-Spark I, and American Motors BID, will show a step condition prior to the first primary oscillation. This condition is normal and not to be taken as a defect.


Found on GM HEI, Ford Dura-Spark I, and AM/IH BID when in the shift mode.

5.7 Mechanical Point Action

The purpose of the points is to make and break the primary coil current at all engine speeds. How well the engine points operate can be observed by watching the coil collapse at various engine speeds.

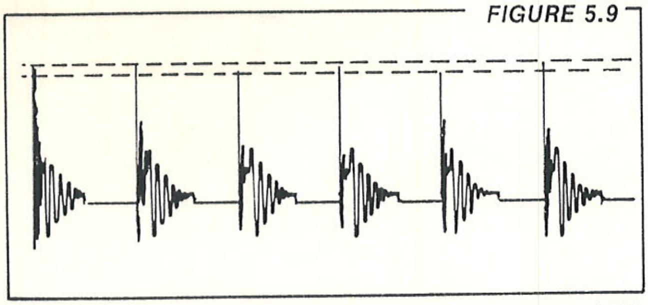
- Select the off pushbutton in the sweep selector and the parade pushbutton in the pattern selector

OFF ☐

- Slowly increase the engine speed while observing the screen viewing area. (Figure 5.9)

PARADE ☐

FIGURE 5.9



All cylinders should show their peak oscillations fairly equal (within 2 KV) throughout the RPM range (0-2000 RPM).

A new set of points may produce variations in peak height. However, they will eventually seat.

If the height of the oscillations bounce all over the place, note the speed range during that time.

SPEED	CAUSE
Idle to Low	Badly seated points High contact resistance Misalignment
Med to High	Floating points Spring tension
One cyl only	Worn or dirty cam

5.8 Primary Reflected in the Secondary

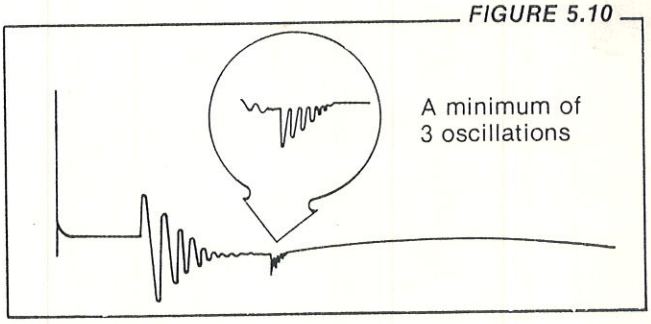
Since the primary coil condition directly effects the secondary circuit, some primary problems can be noted in the secondary pattern.

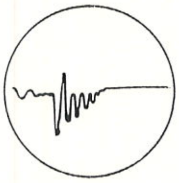
20 KV LO CO ☐ **SELECT THE 20 KV/LO CO PUSHBUTTON**

When the engine points close, a build-up of primary current is initiated. This condition can be seen in the secondary pattern at the beginning of coil saturation (dwell).

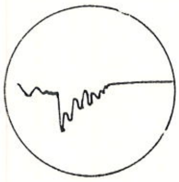
Figure 5.10 shows the normal build up point. Any deviation from normal at this point should be closely examined.

FIGURE 5.10

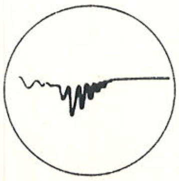




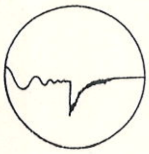
BOUNCING POINTS
Usually acting up at high speed. The points do close properly, but momentarily open and charge up the condenser.



PITTED POINTS
May or may not coincide with arcing points. Produces erratic or intermittent build up of primary coil current.

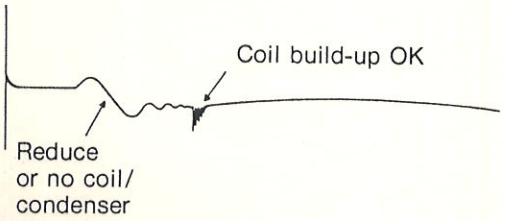


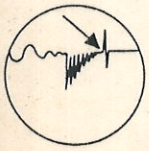
CONTACT RESISTANCE
There is a delay in the seating of the points causing losses of the first oscillation.
(May be typical with new points)



DEFECTIVE COIL
Refer to Figure 5.5 when coil/condenser oscillations have been reduced or "killed". The points close signals a likely defective coil when these oscillations are also "killed".

However, when the coil oscillations are present but the coil/condenser oscillations are not, likely the problem is due to a defective condenser.





LOOSE CONNECTION
The poor connection can be anywhere in the primary circuit when the symptom wanders all over the dwell.
If it is steady, the problem is related to the engine points.

Any defect found in the primary circuit will usually display the trouble common to all cylinders in the secondary circuit. Generally, when only one secondary cylinder displays a defect, the problem will be found in that cylinder.

SECTION SIX

Satisfactory engine performance and economy depend on proper timing of the spark.

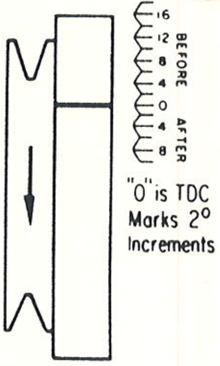
PREPARATION BEFORE TIMING

- Dwell corrections should always preceed timing adjustments.
- Disconnect vacuum lines from the distributor and plug with golf tees.
- Clean off and chalk the timing mark
- Do not take RPM for granted, adjust the engine speed to the manufacturers specifications.

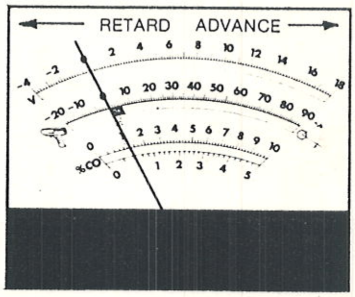
6.1 Initial Timing

TIMING ☐ **SELECT THE TIMING PUSHBUTTON**

- Set the conditions of the engine according to manufacturers specifications.
- Turn the timing light "advance" control to the full "off" position.
- Aim the timing light towards the timing mark and depress the trigger and adjust the timing according to the manufacturers specifications.

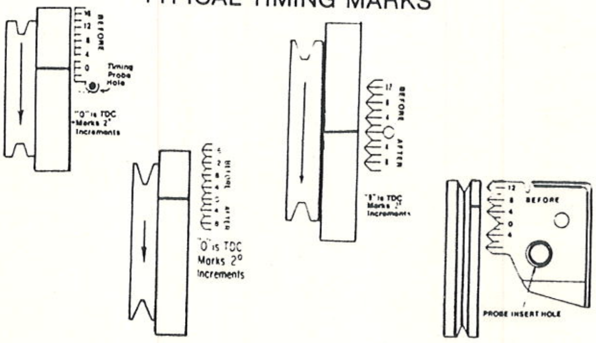


Use the damper pulley index for initial timing adjustments instead of the advance meter.



The advance meter will read either retard degrees or advance degrees.

TYPICAL TIMING MARKS



II. CENTRIFUGAL ADVANCE

Leave the vacuum hose off of the distributor and bring the engine speed to approximately 2000 RPM.

- Use the "Advance Control" on the timing light to bring the pulley mark back to the initial timing setting. Read the advance meter and note on the diagnostic report.
- Consult the manufacturers specifications . . . typically the centrifugal advance is between 15 - 20 degrees.

III. TOTAL ADVANCE

For total advance, reconnect the vacuum hose to the distributor and repeat the test as in centrifugal advance above.

This condition includes the centrigufal and vacuum advance together. The difference between centrifugal and total advance is the vacuum advance:

EXAMPLE

38° — 20° = 18°

Centrifugal . . . . .20°
Total . . . . .38°
Vacuum . . . . .18°

SECTION SEVEN

50 KV HI CO	SELECT THE 50 KV/HI CO PUSHBUTTON

7.1 Coil Polarity

The purpose of this test is to determine whether the coil or battery is connected properly.

- Select the "superimposed" pushbutton in the sweep selector.

The pattern in Figure 7.1 shows the incorrect polarity. Generally this can be corrected by reversing the wires on the coil. Quickly check first to see that the battery has been installed correctly.

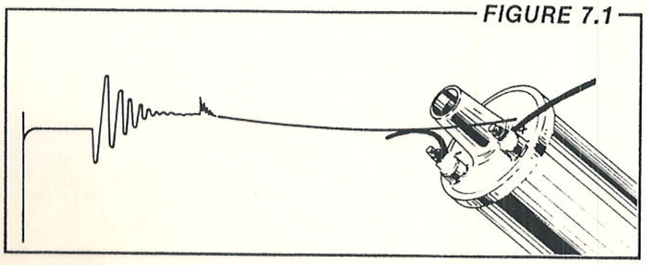


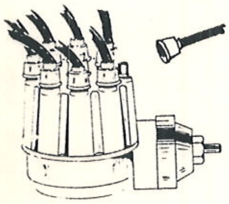
FIGURE 7.1

Incorrect coil polarity can reduce the secondary voltage as much as 40%. This could result in high speed misfire.

7.2 Coil Output

The purpose of this test is to determine the maximum available KV output of the coil while open circuited. For high energy electronic ignition systems, see Note below.

- Select the "parade" pushbutton in the pattern selector.
- Disconnect one of the spark plug wires from the distributor cap and observe the screen display as shown in Figure 7.2



NOTE: On GM HEI and Ford Dura-Spark I systems, it is not recommended that any wire is disconnected for coil output measurements. Use the firing time approach to coil output as described in Section 8.3 (Plug firing time).

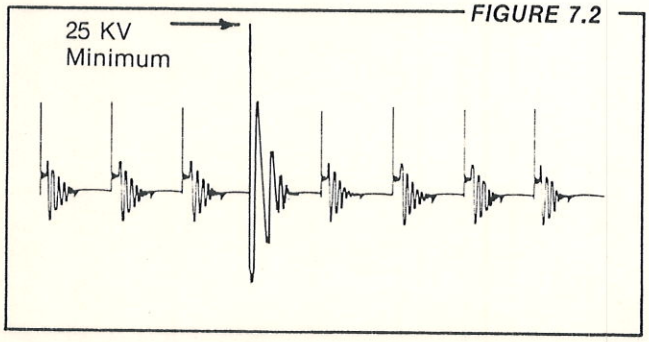


FIGURE 7.2

A minimum of 25 KV is an acceptable voltage for most engines. However, check the manufacturers specifications.

Input primary current is an important determining factor for coil output. Check primary resistance as described in Section 5.2.

While observing the open plug wire pattern look for the presence of a firing line as shown in Figure 7.3. Leakage is the result of a loss to ground due to a carbon track in the rotor or cap (either an internal or external condition).

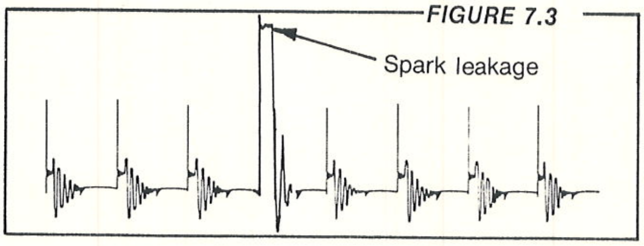
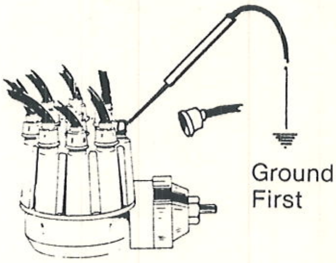


FIGURE 7.3

7.3 Rotor Air Gap

The purpose of this test is to measure the voltage required to jump the air gap between the rotor and the distributor cap.

- Insert a grounded probe into the terminal of the distributor cap at the place where the wire is removed. (Be sure the probe clip is grounded first).



- Observe the screen display and note the maximum height of the spike for that cylinder (See Figure 7.4).

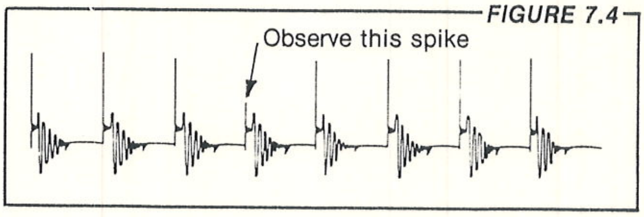


FIGURE 7.4

The spike height should not exceed 7-8 KV for most engines. If so, a wide gap is indicated and may result in engine crossfire, especially if the timing is off.

- Reinstall the spark plug wire.

7.4 Plug Firing Voltage

The purpose of this test is to determine the required voltage needed to ionize the plug gap in each cylinder.

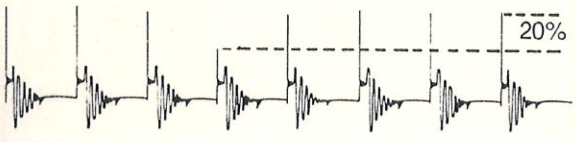
The relative difference in plug firing voltage should not exceed 20%.

Each cylinder will require different levels depending on the engine conditions. Older cars are generally in the range of 8KV while later cars with emission controls usually require up to 15KV due to their leaner mixtures.

The pattern shown in Figure 7.5 illustrates the extent of the difference in spike height that is acceptable.

FIGURE 7.5

It is more important to look for the difference in spike height between cylinders than the actual KV requirement.



Determine whether one, more, or all cylinders are affected by high, low or fluctuating conditions.

Cyl.	High	Low	Fluctuate
One/ more	1. open plug wire 2. wide plug gap	1. fouled plug 2. low compression	1. carb or carb adj
All	1. mixture lean 2. vacuum leak in carb. 3. worn plugs	1. mixture rich	1. extreme lean mixture

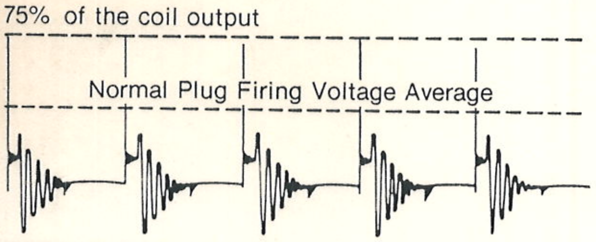
7.5 Plug Firing Voltage Under Acceleration Check

The purpose of this test is to observe the voltage demand at sudden accelerations. Before the accelerator pump has had a chance to richen the fuel mixture, a momentary "lean mixture" will cause the voltage requirement to increase. This test will help to determine worn out plugs and wide plug gaps.

- Let the engine stabilize at 800-1000 RPM
- Quickly "snap the throttle" and release, not allowing the engine to race.

The sudden increase in spike height should not exceed 75% of the maximum available voltage (Section 7.2) (See Figure 7.6).

FIGURE 7.6



SECTION EIGHT

25 KV
.O CO ☐ **SELECT THE 25KV/LO CO PUSHBUTTON**

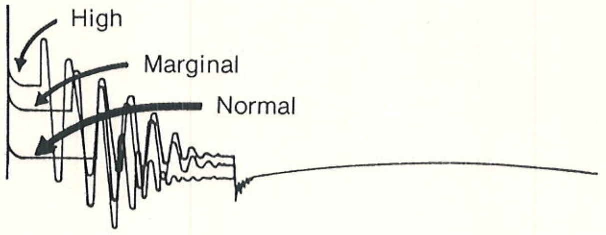
.1 Secondary Resistance

he purpose of this test is to determine the condition of he spark plug wires.

- Select the "superimposed" pushbutton in the pattern selector.

Shown in Figure 8.1 is an example of a plug wire with xcessively high resistance, one with a marginal condiion and the normal plug firing voltage.

FIGURE 8.1



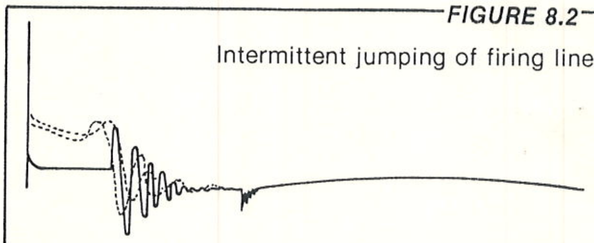
The high condition is typically the result of too much secondary resistance. This will weaken the strength of the spark and shorten the time of spark duration.

8.2 Value Action

High secondary resistance is also indicative of lean fuel mixtures. If the resistive condition is of an **intermittent** nature, the problem is not likely due to a spark plug wire but rather due to a variation in fuel mixture.

Since the valves control the fuel mixture from stroke to stroke, an intermittent condition (Figure 8.2) is likely due to sticky or poorly seating valves.

FIGURE 8.2



Intermittent jumping of firing line

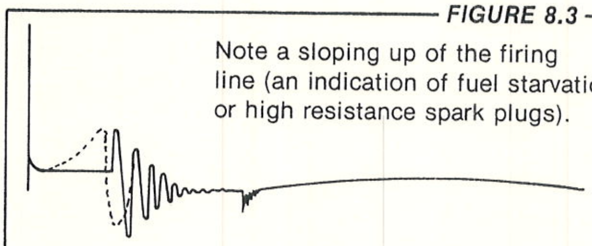
In some cases a simple oil change will correct the problem, however, this depends on the extent of the problem.

Sticky valves will usually cause a floating condition at higher engine speeds.

- Set the engine speed to approximately 1500 RPM.

Floating valves will tend to starve the combustion chambers for fuel. This will cause the spark to "give out" sooner and cause an increase (sloping up) of voltage to sustain the spark (Figure 8.3)

FIGURE 8.3



Note a sloping up of the firing line (an indication of fuel starvation or high resistance spark plugs).

8.3 Plug Firing Time

The purpose of this test is to determine the length of time the spark occurs.

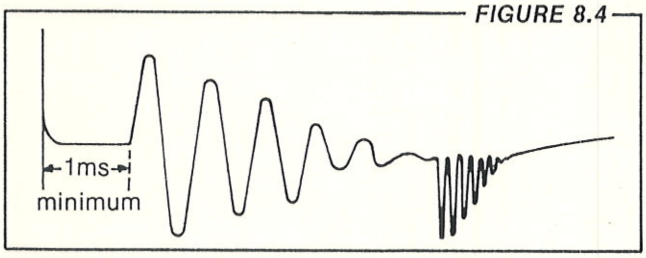
In order to obtain total combustion, it is important to sustain a spark for as long as combustible mixtures are present within the chamber.

Typically the spark duration is 1/1000 second (one millisecond) or slightly longer.

The most contributive factor to the length of the spark duration is the available KV output while plug gap and fuel conditions alter the spark duration only slightly.

If the spark duration time is adequate it can be assumed that the entire ignition system is in suitable condition (see Figure 8.4).

FIGURE 8.4



- Select the "5 ms" pushbutton in the sweep selector
- Observe the screen display. Each division mark is equal to one millisecond of time for a total of 5ms in this mode.

The available KV output of the ignition coil is dependent on many factors.

1. Primary resistance
2. Coil/condenser condition
3. Point resistance
4. Dwell
5. Coil polarity

The demand on the ignition system is dependent on many factors.

1. Plug firing voltage
2. Plug gap
3. Rotor-air gap
4. Plug wires
5. Secondary resistance
6. Fuel and valve conditions

The firing time should therefore be equal for all cylinders over the entire speed range.

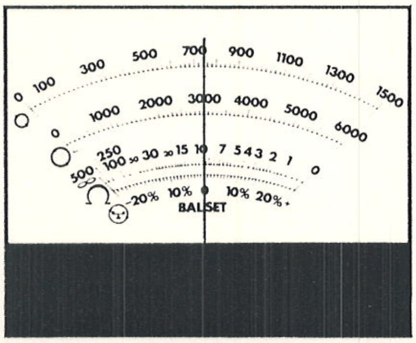
SECTION NINE

CYL BAL ☐ **SELECT THE CYL BAL/ CARB ADJ PUSHBUTTON**

9.1

The purpose of this test is to determine the engine performance by comparing engine efficiency per cylinder.

- Allow the engine to idle.
- Select the "superimposed" pushbutton in the pattern selector and the "off" pushbutton in the sweep selector.
- Adjust the engine speed between idle and 1000 RPM.
- Use the "bal. set" control to adjust the cylinder balance meter to center scale (zero set)



- Select individual cylinders (one at a time) from the cylinder select and depress the "cyl short" pushbutton (NOTE: These pushbuttons push-to-select and push-to-release)

☐ **CYL SHORT**
☐ 1
☐ 2
☐ 3
☐ 4
☐ 5
☐ 6
☐ 7
☐ 8

- Observe the change in the cylinder balance meter and record the percent (%) of change for each cylinder on your diagnostic report sheet.

The ideal condition is that all cylinders record the **same** amount of change, not how much they change. As long as all cylinders record equal, no problem is apparent. However, when one or more cylinders show "low" or "no change", a problem exists with those cylinders.

Variations of more than 1% change as shown on the blanace meter should be considered a problem.

Cylinder	1	2	3	4	5	6	7	8
% reading	5	5.5	5	4	4.5	5	5.5	3.5

In the example above, the #8 cylinder in the firing order is low, the rest of the cylinders are between 4.5% and 5.5%.

It is always good practice to repeat the test to be sure the readings conform.

The second time through they may vary slightly but the same high/low conditions should show.

- At the same time as the cylinders are being shorted note the KV (initial spike height) level of that particular cylinder.

Cylinders	KV	Possible Problem
one/more dead	High	open plug/open wire
one/more dead	Low	Fouled plug/shorted wire
one/more	High	Air leak/compression leak*
Alternate cyl low	High	Carburetor balance/ Intake manifold
two consecutive low	Low	Crossed spark plug wires

*Air leaks and compression leaks demonstrate different problems at higher engine speeds.

- Raise the engine RPM to approximately 1500 RPM.
- Repeat the balance test and record your results.

Engine Speed	Test Results	Likely Problem
Low	Low	Valve
High	Normal	Air leak
Low	Low	Ring/Piston
High	Low	Verify w/compression test
Low	High	Floating valves
High	Low	Weak valve spring

9.2 MULTI CYLINDER BALANCE

The purpose of this test is to determine the combustion efficiency of each bank of cylinders on 2 BBL or 4 BBL carburetor engines.

- Adjust the engine RPM to approximately 1200 RPM.
- Release the KILL pushbutton.
- Select alternate cylinders . . . 1 - 3 - 5 - 7 . . . push the KILL pushbutton and observe the meter.
- Release the KILL and buttons 1 - 3 - 5 - 7 and select buttons 2 - 4 - 6 - 8.
- Push the KILL button and compare both bank results.

The results should be equal for both banks.

Deficiency of fuel in one intake runner could be caused by an unbalanced carburetor or air leak in the manifold.

Adjust the venturi (1/8 of a turn at a time) that corresponds with the intake runner that had the lowest reading until each bank efficiency is equal.

Setting the carburetor idle and air/fuel mixture according to the lean roll method is described in the next section.

9.3 Carburetor Adjust

The purpose is to set the carburetor for maximum idle performance.

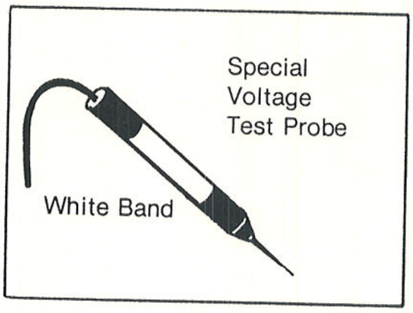
- Adjust the engine to manufacturers idle specifications.
- Set the balance meter to center scale with the "bal set" control.
- Adjust each venturi jet 1/8th of a turn at a time to obtain the maximum meter movement in the plus (+) direction.
- Allow the engine speed to stabilize.
- Turn each venturi leaner until a 1% drop per venturi is obtained on the meter.
- Reset engine idle speed to the manufacturers specifications.

SECTION TEN

2 VOLT SPEC **SELECT THE 2 VOLT/SPEC. PUSHBUTTON**

This test mode provides the use of the ohmmeter leads as an isolated 0-2 volt meter (use the 0-20 volt scale). Also a special test probe is provided which will allow measurement of voltage changes displayed on the screen (0-50 volts).

There are many interesting tests that can be formed in his mode.



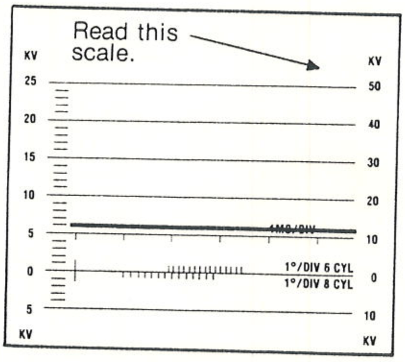
The special voltage test probe can be used to trace voltage problems in circuit malfunctions in starting and charging systems, ignition systems, air conditioning and heating systems, auto temperature control, headlight and taillight systems, stop, turn and hazard flasher and seat belt warning systems or any system that operates off of voltage supplies. Any of these circuits can be direct battery voltage, either switched or pulsed through relays or electro-mechanical circuits.

TEST PROCEDURE:

- With the engine harness connected, leave the engine running at idle.
- Use the special voltage test probe.
- Use the special voltage test probe to probe at connectors, contacts, terminals or components in the circuit under test.
- Observe the pattern display on the screen viewing area.

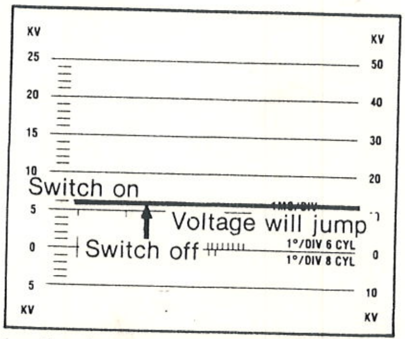
If the circuit is direct battery voltage, such as the battery terminal of the ignition switch, the screen viewing area will display a straight line wave form at the level proportional to the amount of voltage.

The example to the right shows the trace line raised to the 12 volt level as observed on a 0-50 volt scale. This line indicates that battery voltage is present at the contact tested.



If the circuit is switched through a control device, such as the ignition terminal of the ignition switch, the screen viewing area will display the voltage waveform at the zero level while the ignition switch is off and will jump to the battery voltage level when turned on.

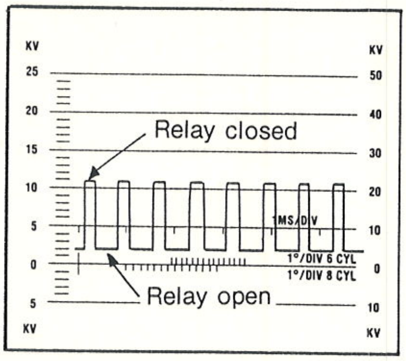
Example: Test probe at the ignition terminal or the ignition switch while the key is off



Turn the key to on and the voltage should jump to the battery voltage level if the switch is good.

If the voltage is controlled by a constant operation relay, such as the relay (or electronic device) in a voltage regulator, the voltage will constantly pulse as the relay opens and closes.

Example: The pulse shown to the right displays the action of the voltage control relay for the field winding of the alternator. Each time the relay closes the voltage rises to its limits.



It is impractical to display all of the waveforms that can be observed on the screen for the many different test circuits that can be encountered.

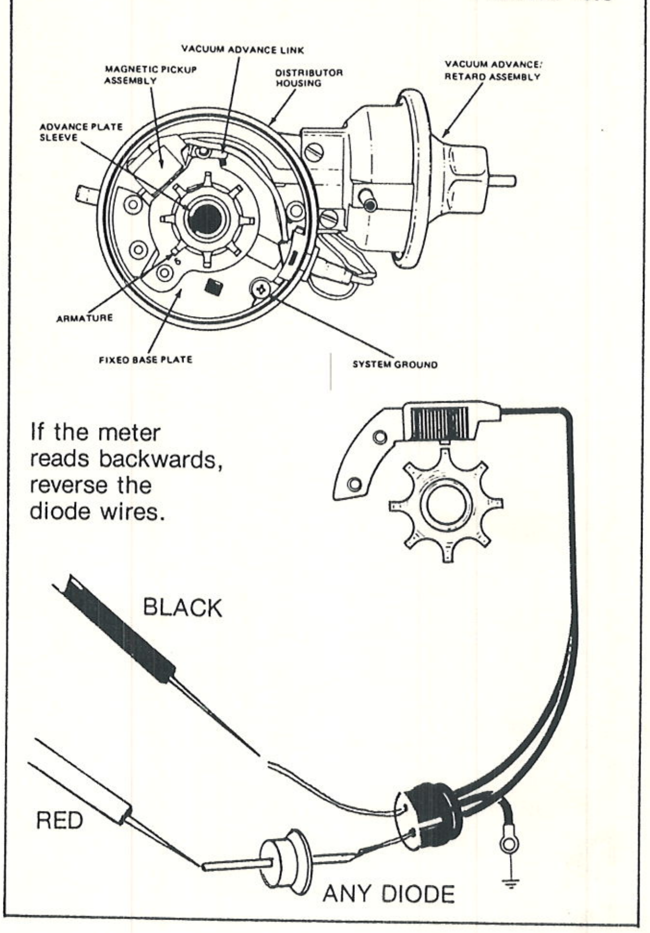
Keep the basic three patterns as previously described in mind and reference the manufacturers service manual electrical wiring diagrams for test points and locations of interest.

CHECKING THE MAGNETIC PICK-UP

The chart below identifies continuity and voltage tests for the magnetic pick-up and ignition coil.

The diagram to the right shows the hook-up for measuring the voltage output of the pick-up while the engine is cranking.

FIGURE 10.5



If the meter reads backwards, reverse the diode wires.

FORD TEST	POSITION	BLACK	RED	RESULT
Magnetic Pick-up Continuity	R x 1	Purple Wire on Distributor	Orange Wire on Distributor	400 - 800 ohms
Primary Resistance Ignition Coil	R x 1	Coil "DEC" Terminal	Coil "BAT" Terminal	1 - 3 ohms
Secondary Resistance Ignition Coil	R x 1000	Coil H.T. Tower	Coil "BAT" Terminal	7000-9000 ohms
Magnetic Pick-up Voltage Output	Lo Volt /Spec.	Purple Wire on Distributor	Orange Wire on Distributor w/Diode (Fig. 10.5)	Crank engine for 10 sec. .5 volts/more at 80 RPM/more

Except for the DURA-SPARK I system, the electronic module provides coil current when the ignition key is ON. when the ignition key is turned OFF, a spark from the coil will occur.

- Disconnect the high tension wire from the distributor cap and place the wire approximately 1/2" from ground.
- Turn the ignition key ON and OFF and watch for a spark.

If no spark occurs and ALL of the ABOVE TESTS have BEEN MADE, the electronic module may be defective. However, there may also be a defect in the wiring harness . . . ohm the wires from point-to-point for continuity or jump each wire out one at a time.

NOTE: When ohming the wires, disconnect the battery + cable first.

GM HEI TEST	POSITION	BLACK	RED	RESULT
Magnetic Pick-up Continuity	R x 1	White Wire of Pick-up	Green Wire of Pick-up	550 - 1500 ohms
Primary Resistance Ignition Coil	R x 1	Distributor Cap "C—" Terminal	Distributor Cap "B + Terminal	0.2 - 1.5 ohms
Secondary Resistance Ignition Coil	R x 1000	High Tension Output Terminal	Distributor Cap "B + " Terminal	12,950 ohms
Magnetic Pick-up Voltage Output	Lo Volt/Spec.	White Wire of Pick-up	Green Wire of Pick-up w/Diode (Fig. 10.5)	Crank engine for 10 sec. .5 volts/more at 80 RPM/more

The GM HEI module DOES NOT provide coil current until the timer core teeth rotate within the magnetic pick-up.

CHRYSLER TEST	POSITION	BLACK	RED	RESULT
Magnetic Pick-up Continuity	R x 1	Distributor Wire Male Pin	Distributor Wire Female Pin	400 - 600 ohms
Primary Resistance Ignition Coil	R x 1	Coil "—" Terminal	Coil " + " Terminal	1 - 3 ohms
Secondary Resistance Ignition Coil	R x 1000	Coil " + " Terminal	High Tension Output Tower	9000 - 12,000 ohms
Magnetic Pick-up Voltage Output	Lo Volt/Spec.	Distributor Wire Male Terminal	Distributor Wire Female Terminal w/Diode (Fig. 10.5)	Crank engine for 10 sec. .5 volts/more at 80 RPM/more

The Chrysler electronic module provides coil current when the ignition key is ON. When the ignition key us turned OFF a spark will occur from the coil tower. Perform tests as identified in FORD above.

AM TEST	POSITION	BLACK	RED	RESULT
Sensor Coil Continuity	R x 1	Distributor Wire Male Pin	Distributor Wire Female Pin	0.8 - 3.0 ohm
Primary Resistive Ignition Coil	R x 1	Coil "—" Terminal	Coil " + " Terminal	0.7 - 2.5 ohm
Secondary Resistance Ignition Coil	R x 1000	Coil " + " Terminal	High Tension Output Tower	8,000 - 16,000 ohm
Sensor Coil Short to Ground	R x 1000	Distributor Wire Male Pin	Distributor Ground	Infinity

The AM module will provide coil current when the ignition switch (key) is ON. Perform test as in FORD above.

Isolated Voltmeter Measurements

For voltage drop measurements or terminal voltage other than the battery, the isolated voltmeter may be used.

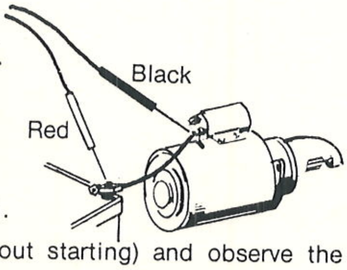
VOLTS **Rx1** **Rx1000**

☐ ☐ ☐

- Select the volt pushbutton and use the red and black volt/ohm lead set.

Battery & Solenoid Cable Check

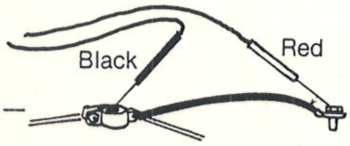
If the cranking current is fairly normal, but the cranking speed is far below acceptable limits, some of the battery energy may not be getting to the starter.



This energy can be lost in the cables, connections and solenoid.

- Place the red probe directly on the starter solenoid terminal and the black probe on the positive battery terminal.
- Crank the engine (without starting) and observe the voltmeter—no more than a .7 volt reading should be observed.

  Replace positive battery cable if more than .7 volts
- If OK, (.7 volts or less), place the red probe on the engine block ground and the black probe on the negative battery terminal.
- Crank engine and observe the voltmeter—no more than a .7 volt reading—

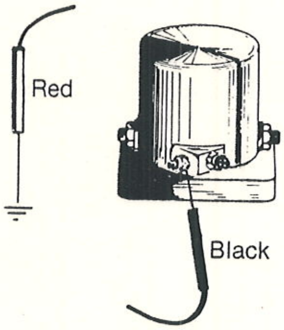


Replace negative battery cable if more than .7 volts.

Replace solenoid if both volt readings are .7 volts or less.

Solenoid Ignition Terminal Check

If the solenoid doesn't click when the ignition key is placed in the start condition—check as follows:



- Connect the red probe to one of the ignition terminals and the black probe to the negative battery terminal.
- Turn the key to the start position and observe the voltmeter —should be 12 volts.
- Move the red probe to the other solenoid ignition terminal and repeat.

If one ignition terminal reads 12 volts while the other doesn't, replace the solenoid.

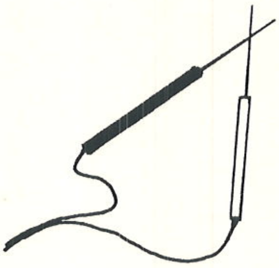
If both read 12 volts look for open ground.

If neither read 12 volts look for starter switch problems.

Ohm (Resistance) Measurements

Select either the x1 or x1000 pushbutton and calibrate the ohmmeter.

- Short the ohm leads together and adjust the front panel zero control for a zero ohm meter reading.

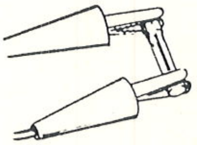


Check lamps, wires, fuses, diodes, etc. for continuity or resistance.

NOTE: For circuit projection it is recommended that the positive battery cable is disconnected while making resistance tests to components while they are still in their circuit.

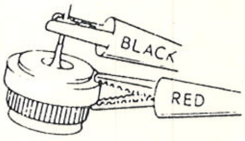
Fuse Testing

- Connect the test probes across the fuse body and observe continuity.

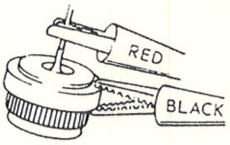


Diode Testing

- Connect the red probe to the large body of the diode and the black probe to the wire of the diode—measure high resistance.

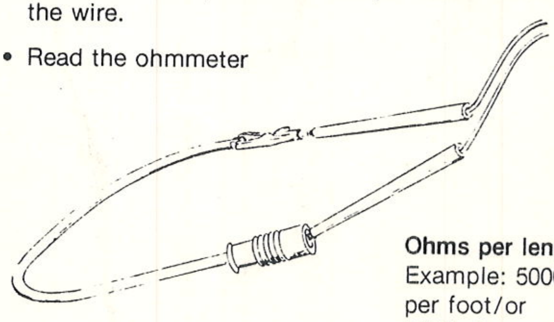


- Reverse the test probes and measure low resistance.



Spark Plug Wires

- Consult the manufacturers specifications for resistance per length and place the test probes at both ends of the wire.
- Read the ohmmeter



Ohms per length
Example: 5000 ohms per foot/or
1000 ohms per inch typical.

American Motors BID (Breakerless Inductive Discharge)

The American Motors ignition system is an electronically controlled system that "makes" and "breaks" the primary coil current similar to the points in any conventional ignition system.

The Electronic Control Unit (ECU) regulates the primary current and eliminates the need for a ballast resistor or resistance wire.

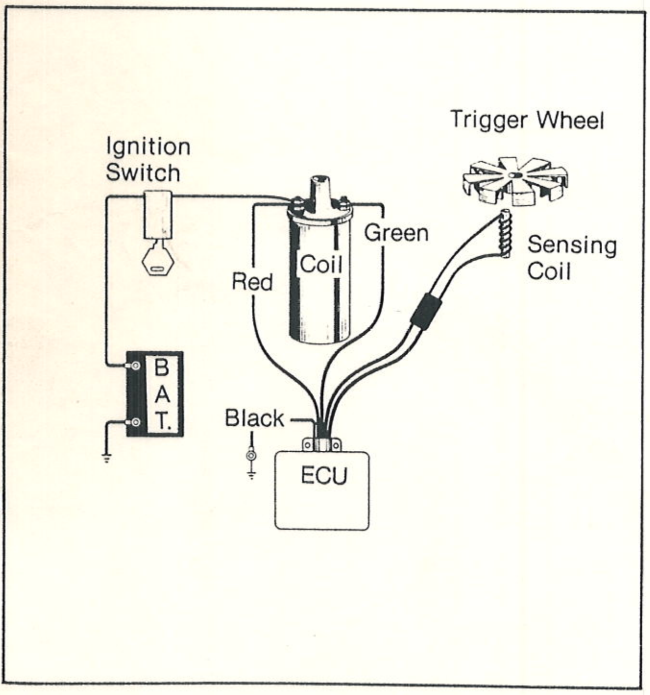
This system uses a sensing coil and a trigger wheel which are located in the distributor.

The sensing coil is part of a high frequency oscillating circuit. When the coil is left to operate freely the ECU will provide primary coil current.

However, when the trigger wheel passes over the top of the coil the high frequency oscillations become loaded. Much in the same way a car radio will "fade" when passing under an overpass.

This load or loss of oscillation strength will signal the ECU to stop the primary coil current. Consequently, the magnetic field will collapse and induce a high voltage into the secondary circuit.

Shown below is an illustration of the American Motors Electronic Ignition System.

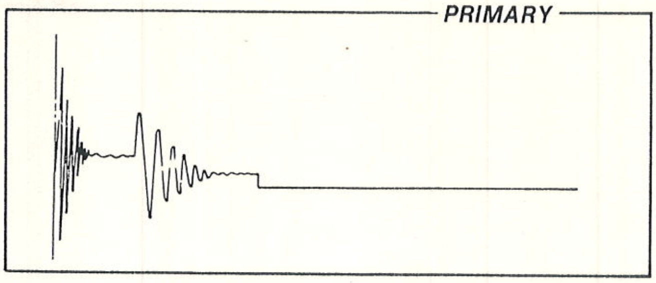


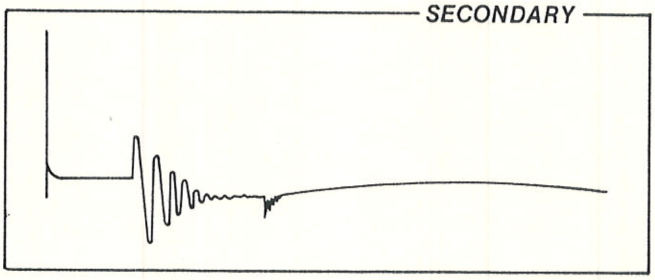
Hook-up and testing of this system is to be accomplished in the same manner as with any conventional ignition point system.

The differences in testing are with the points resistance and dwell readings, although the meter will provide a reading. In either case, they are non-adjustable conditions.

However, the IH BID is very similar except that this system has dwell specifications and can be adjusted by changing the sensor coil airgap to the trigger wheel.

Also notice a slight variation in the primary and secondary patterns.





Analysis of this pattern is to be done in the same manner as with the standard ignition patterns.

———Special Note About——— Engine Spark Knock (Ping)

Spark knock can be attributed to a number of factors. The most common are climatic conditions, such as temperature, air density, and humidity—and, of course, ignition timing and fuel.

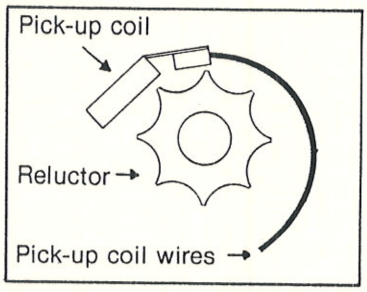
All AM engines with the breakerless inductive discharge system (BID) are designed to operate on unleaded fuels. Fuels of equivalent octane rating may vary in their knocking characteristics in a given engine.

It may be necessary to retard the timing (up to but not more than 2° from the initial setting) or select an alternate source of fuel to eliminate "spark knocking".

Chrysler Electronic Ignition

The Chrysler Electronic Ignition System consists of a battery, ignition switch, dual ballast resistor, coil, electronic control unit and distributor.

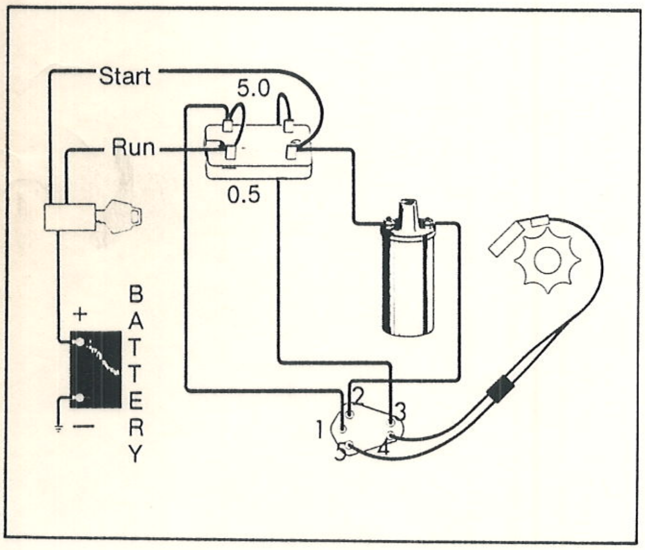
The distributor uses a magnetic pick-up coil and rotating reluctor. As the reluctor rotates past the pick-up coil, a voltage pulse is induced each time the spark plug is to fire.



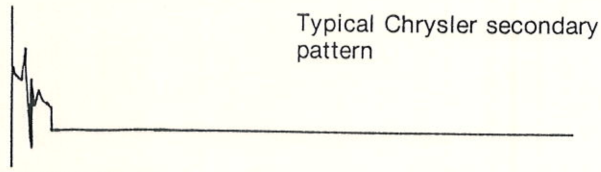
This pulse is applied to the electronic module where it signals the module to stop the primary current. After a pre-determined time (controlled by the module) the primary current starts to flow once again through the coil.

The dual ballast resistor consists of a 0.5 ohm compensating primary circuit resistor and a 5.0 ohm control unit feed resistor.

The compensating resistance (0.5 ohm) maintains a constant primary current with variations in engine speed. During starting conditions the primary ballast is by-passed, applying full battery voltage to the ignition coil.



The Chrysler unit is to be checked in the same manner as a conventional ignition system except for the "dwell" (no adjustment).



Typical Chrysler secondary pattern

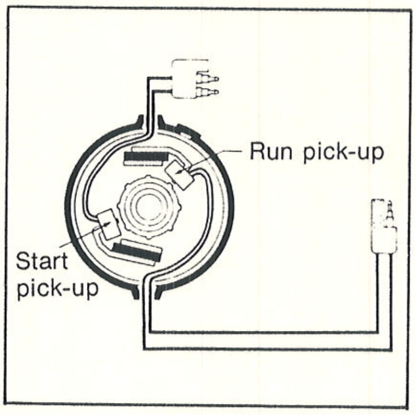
Chrysler Electronic Lean Burn System.

The electronic lean burn system consists of a "spark control computer", various engine sensors, and a specially calibrated carburetor.

The spark advance is primarily controlled by the "spark control computer" which receives its signals from engine sensors.

The distributor contributes only a centrifugal advance to the spark.

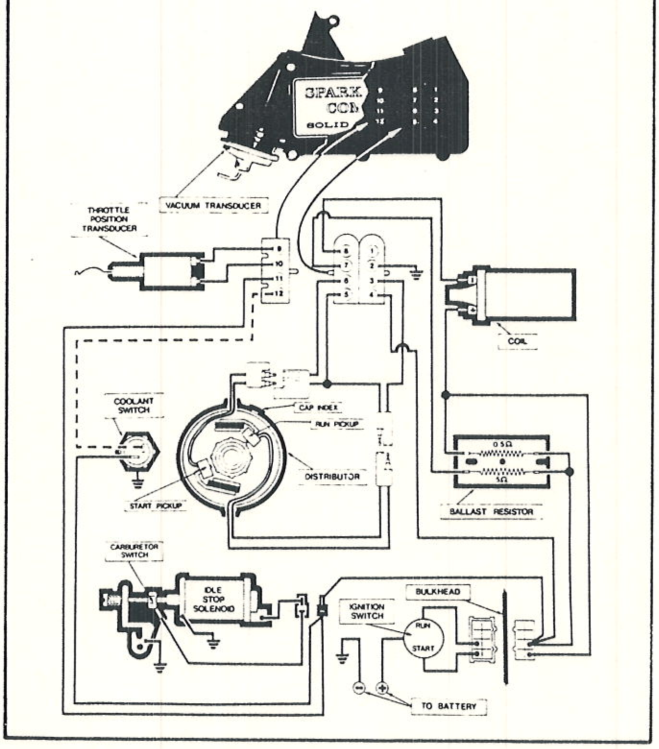
Located in the distributor are two pick-up coils. One coil operates during starting conditions, while the other coil operates during run conditions. The "computer" controls the selection of either the start or run coils, not the ignition switch.



The start pick-up is easily identified by having the larger of the two distributor connections.

Note also that no vacuum advance mechanism is connected to the distributor.

Electronic Lean Burn Wiring Diagram



- **Coolant Temperature Switch**—located on the water pump housing—signals that the engine temperature is below 150° F.
- **Air Temperature Sensor**—located in the computer—incoming fresh air temperature controls "throttle position" advance.
- **Throttle Position Transducer**—located on the carburetor—signals the computer to advance with throttle plate position change and rate of change.
- **Carburetor Switch**—located on the right side of the carburetor—tells the computer if the engine is at idle or off idle.
- **Vacuum Transducer**—located on the computer—signals the computer to give more advance with higher vacuum and less advance with lower vacuum. The computer responds over a period of time rather than as a direct interpretation.

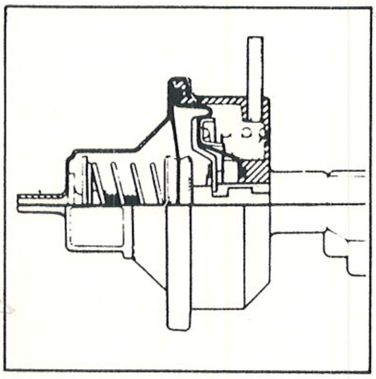
Ford Electronic Ignition

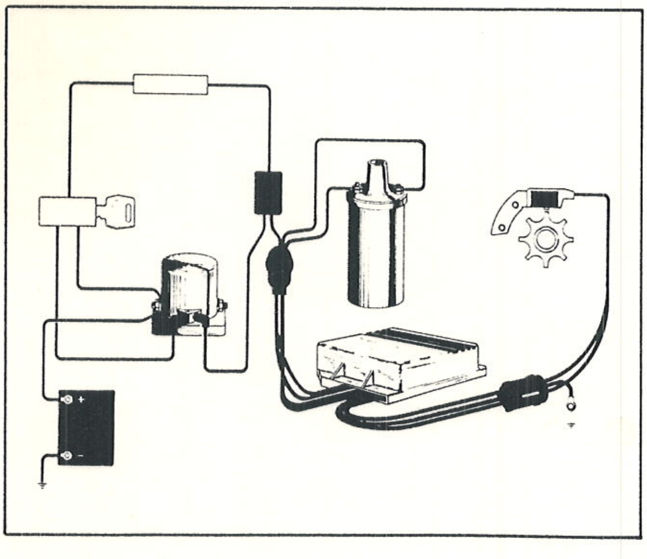
The Ford Electronic Ignition System consists of a battery, ignition switch, primary circuit series resistance wire, ignition coil and distributor with an electronic current control module. The distributor houses a magnetic pick-up coil and rotating armature (reluctor).

When the ignition switch is "on" the electronic module will provide primary coil current. As the armature rotates past the pick-up coil a voltage pulse is induced which signals the module to stop the coil current. A timing circuit within the module will turn the primary coil current on again, after the coil field has collapsed.

The vacuum advance mechanism on this distributor is a dual diaphragm unit that operates from two independent vacuum sources. The outer diaphragm operates from the carburetor port while the inner diaphragm operates from the intake manifold.

During closed throttle positions the intake manifold vacuum is stronger and will retard the timing. As the throttle plate is opened, the ported vacuum increases and exerts a pull against the larger diaphragm spring and thereby creates the necessary advance condition for higher engine RPM.





Engine hook-up and circuit analysis of this system is to be done in the conventional manner with special consideration to dwell.

Since the module determines the turn-on time for primary coil current, no dwell adjustment is necessary.

Ford Dura-Spark I & II

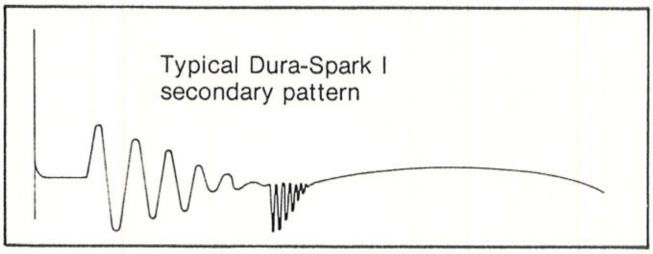
For 1977, Ford has two ignition systems. All California passenger cars, except those with the 2.3L engines, are equipped with the high energy system—"Dura-Spark I".

The Dura-Spark I system has a new low impedence ignition coil, electronic module, distributor cap and wiring, and uses wide gap spark plugs.

The electronic module adjusts the primary coil current for maximum spark efficiency by adjusting the dwell with changes in engine RPM.

When the ignition key is **on** and the distributor is **not** turning, the electronic module will turn the coil current **off**.

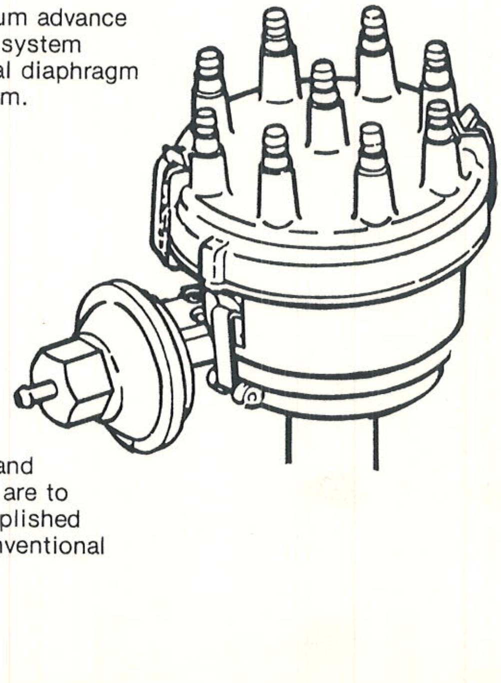
Hook-up and analysis of the Dura-Spark I system is accomplished in the conventional manner except for dwell (variable with engine speed and not adjustable) and the patterns will be shifted slightly (a normal condition).



For all other engines, the Dura-Spark II system is used. This system is basically the same as the 1976 electronic ignition system with the following exceptions:

- Ballast resistance has been reduced from 1.35 ohm to 1.1 ohm.
- All new rotor, distributor and cap.
- New high resistance spark plug wires and wide-gap spark plugs.

The vacuum advance on either system is the dual diaphragm mechanism.



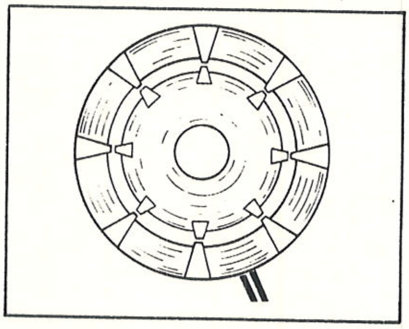
All tests and hook-ups are to be accomplished in the conventional manner.

GM HEI

There are two types of **HEI** systems. The 8 cylinder distributor which combines all ignition components in one unit and the 4 cylinder which has an externally mounted coil.

In either system the contact points are replaced by the pick-up coil and the electronic module.

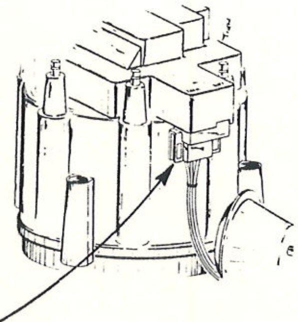
A timer core rotates inside the pick-up coil pole piece. When the timer core teeth align with the pole piece a voltage pulse is induced in the pick-up winding which signals the module to stop the primary coil current and ultimately fire the spark plug.



When the timer core moves out of alignment with the teeth of the pull piece a different voltage is induced which signals the module to start the primary coil current.

Also, the secondary coil energy is greater than in conventional ignition systems which increases the spark duration (a desirable condition for firing lean or **EGR** diluted mixtures).

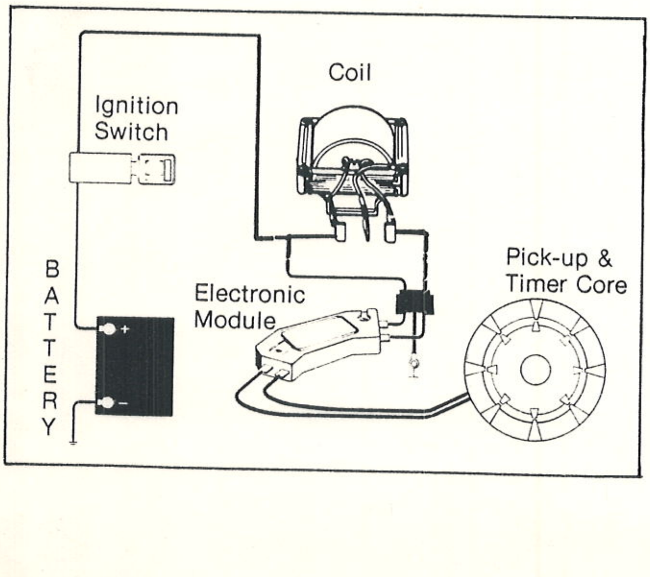
The module automatically controls the dwell period, stretching it with increasing engine RPM.



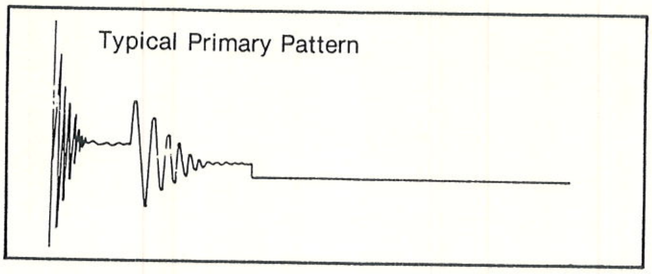
Located in the area of the 3 wire connector from the distributor to the cap is an extended portion of the cap—on the top it is labeled **TACH-BAT**—

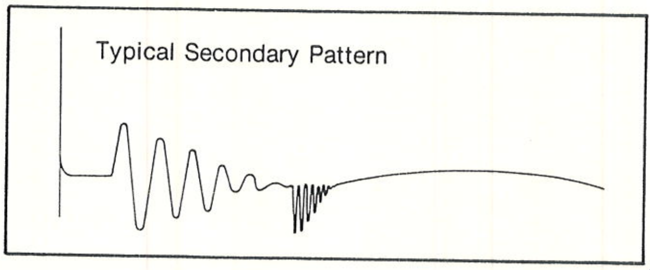
Viewing this extension from below will show two terminals.

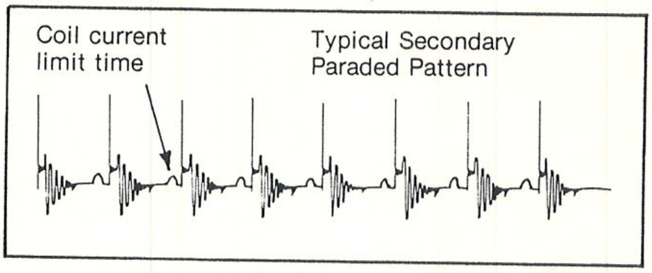
The green colored engine harness clip is to be connected to the **Tach** terminal.



The patterns obtained with the **GM HEI** System will be as shown below.







In the paraded pattern, either the primary or secondary display, a step condition will be noticed just prior to the next cylinder firing.

This condition is the result of the current limit condition which is controlled by the electronic module.

Dwell

Although there are no external adjustments for dwell, the electronic module compensates dwell time with its circuitry as the engine RPM changes.

At idle the dwell reading will generally be about 10° — as engine RPM increases, the dwell will also increase to about 35° at approximately 300 RPM.

This provides us with the indication that the module is "making internal dwell adjustments" with speed as it should.

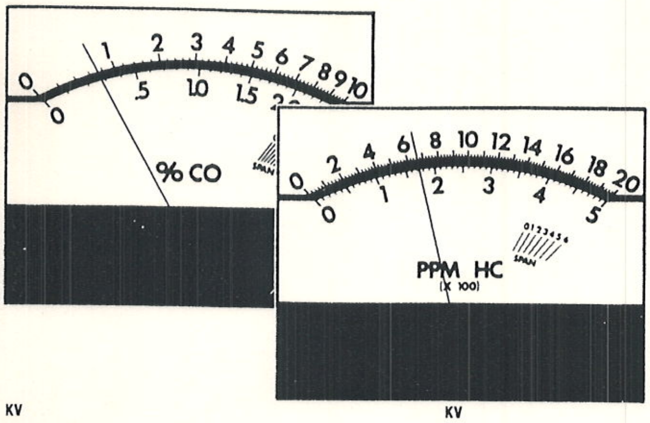
It is not important that the dwell reading is at a particular value, only that it changes with speed.

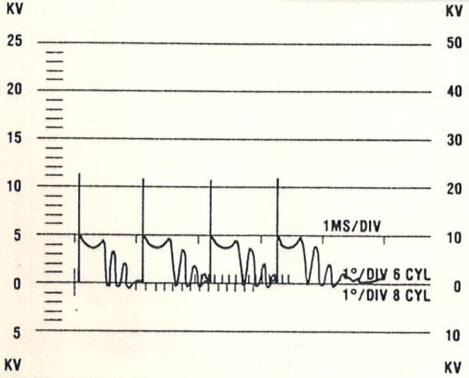
All electronic ignition systems and conventional ignition systems perform the same basic function.

They must fire the plug at the proper time for the proper cylinder.

This principle cannot be altered and therefore all systems should be analyzed in the same manner regardless of whether ignition takes place as a result of mechanical means or electronic means.

Diagnosing with the CO/HC Infra-Red Emission Analyzer & Scope Analyzer





CO
HC
and
KV

WHAT IS CO?

Carbon monoxide is formed by the partial burning of the fuel mixture in the combustion chamber due to a lack of oxygen.

One way of starving the system for oxygen is to provide a rich fuel mixture while another way is to restrict the air intake. Improper carburetion is the major cause of higher than normal CO readings. However, in order for the carburetor to function as designed, air intake must be unrestricted, exhaust, intake, and PCV valves must be operational, engine temperature and manifold vacuum must be correct, ignition and proper ignition timing must take place before the carburetor can be set.

WHAT IS HC?

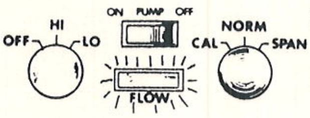
Hydrocarbon is unburned fuel leaving the combustion chamber. Any misfire, regardless of the cause (absence of spark, incorrect timing, compression spark duration, etc.) will contribute to excessive hydrocarbon.

WHAT IS KV?

Kilovolts (1000 volts) is the amount of voltage required to initiate a spark across the plug electrodes. Mechanical, electrical, and fuel conditions all contribute to spark plug demand.

When emissions are incorrect, KV will assist in determining whether the problem is electrical or mechanical.

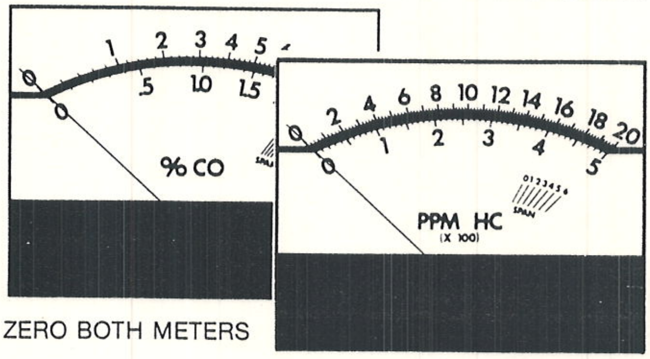
Whatever the cause, proper scope analysis and engine diagnosis is recommended to differentiate between electrical or mechanical problems.



CO/HC Infra-Red Equipment Set-Up

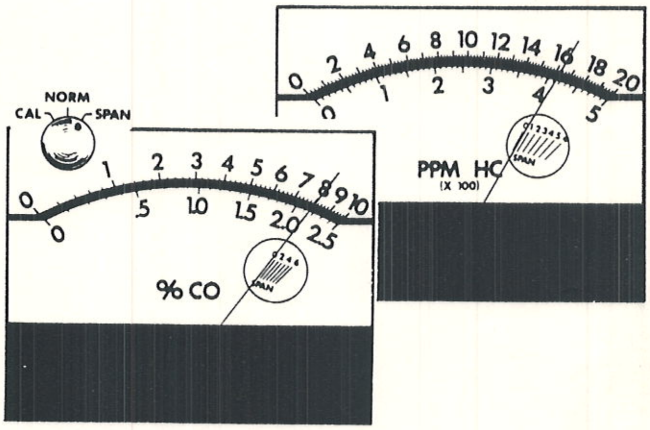
- Select the HI scale operation and place the pump switch in the ON position.
- Allow the analyzer to stabilize for 5 minutes. Check the flow light, it should be on.
- Select the CAL position and zero both the CO and HC meters with the respective zero controls.

The zero controls are a dual control system. The larger outer control is a coarse adjustment which provides a wide range of control, while the inner smaller control is used for fine tuning.



ZERO BOTH METERS

- Select the SPAN position and set both the CO and HC span controls (screwdriver adjustment) so the needle is at YOUR altitude setting.

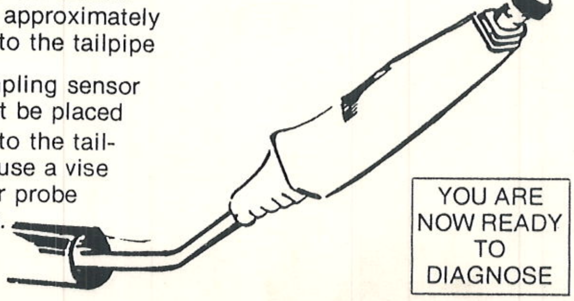


Altitude Above Sea Level	Span Setting
0-1000 feet	0-1
1000-2000 feet	1-2
2000-3000 feet	2-3
etc.	etc.

- Select the NORM position and insert the sensor probe into the tailpipe

Locate the sensor probe approximately 12" into the tailpipe

If sampling sensor cannot be placed 12" into the tailpipe, use a vise grip or probe clamp.



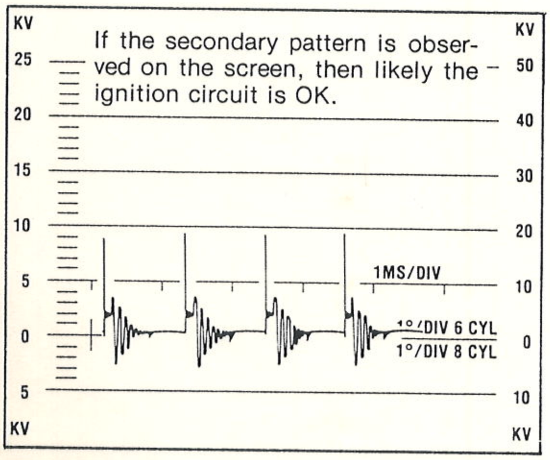
YOU ARE
NOW READY
TO
DIAGNOSE

Testing a "DEAD" Engine

When the engine won't start or won't keep running, the problem can be caused by anything from ignition to fuel starvation.

A 15 second cranking test with the help of the CO/HC analyzer will isolate the problem to fuel or ignition/ignition timing.

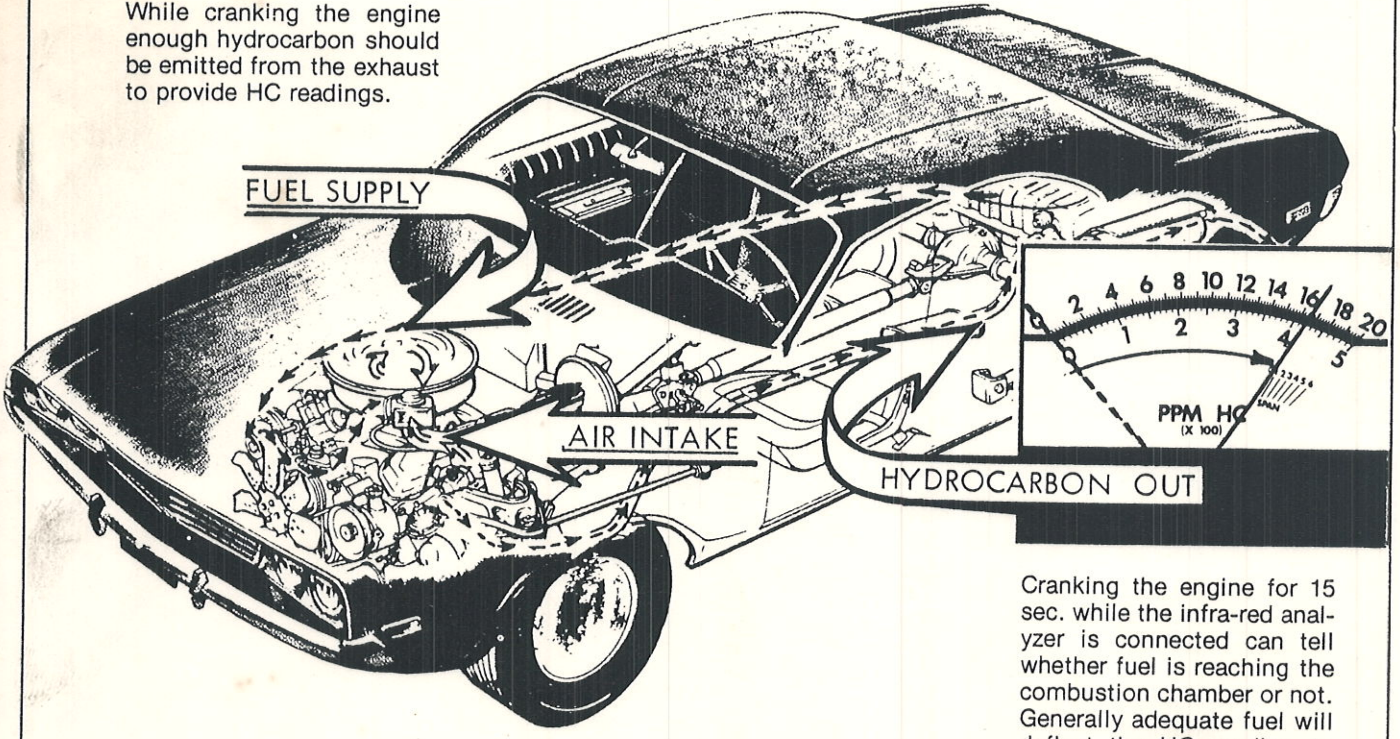
Also while cranking, observe the secondary parade pattern. This display will assist in pinpointing ignition problems.


If the secondary pattern is observed on the screen, then likely the ignition circuit is OK.

TEST RESULTS	POSSIBLE CAUSE
HC READING HIGH OR OFF SCALE	FUEL OK CHECK: 1. IGNITION 2. IGNITION TIMING
HC READING LOW OR NONE	FUEL INTAKE

PARTIALLY BLOCK THE CARBURETOR WITH YOUR HAND	POSSIBLE CAUSE
POOR VACUUM WITH SOME HC INDICATION	1. COMPRESSION 2. AIR LEAK
GOOD VACUUM LOW OR NO HC INDICATION	FUEL SYSTEM 1. GAS IN TANK 2. FUEL FILTER RESTRICTION 3. FUEL PUMP PRESSURE ETC.

While cranking the engine enough hydrocarbon should be emitted from the exhaust to provide HC readings.



Cranking the engine for 15 sec. while the infra-red analyzer is connected can tell whether fuel is reaching the combustion chamber or not. Generally adequate fuel will deflect the HC reading to high or off scale readings.

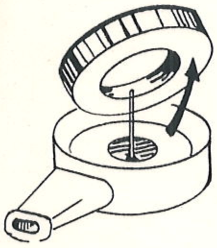
CHECKING THE AIR CLEANER

An air filter may look OK through a light source yet still restrict the air intake.

In order to check the air filter by emissions, a volume of air intake should be created.

- Hold the engine RPM at approximately 2000 RPM and observe the CO scale.

Make a mental note of the % of CO reading.



- With the engine still at approximately 2000 RPM, remove the air filter.

TEST RESULT:

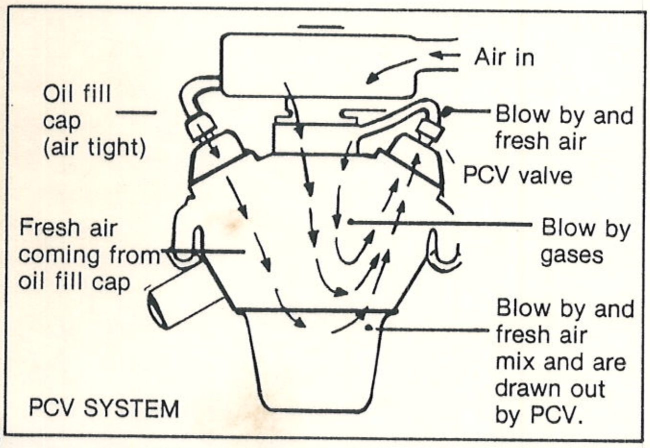
There should be no decrease in % of CO

If the CO drops, an indication of more oxygen is available with the air filter off than with the air filter on.

Remember higher CO is a result of partially burned gasoline due to a lack of oxygen.

CHECKING THE PCV VALVE

The PCV valve is part of a system which controls crankcase contaminates by routing "cylinder blow-by" from the crankcase back to the intake manifold or carburetor base.

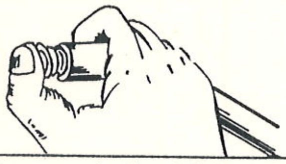

Air in
Oil fill cap (air tight)
Blow by and fresh air
PCV valve
Fresh air coming from oil fill cap
Blow by gases
Blow by and fresh air mix and are drawn out by PCV.

PCV SYSTEM

- Leave the PCV valve connected and let the engine idle.
- Observe the % of CO and make a mental note of the reading.
- Disconnect the PCV valve from the valve cover leaving the hose connected to the carburetor.

  There should be a slight decrease in % of CO.

- Block off the PCV valve with the thumb or finger and observe the % of CO.



There should be a slight increase in % of CO over the initial reading.

Since CO is a measure of partially burned gasoline due to a lack of oxygen, when the PCV valve is open to fresh air, a greater amount of oxygen is carried into the carburetor or intake manifold thereby reducing the CO.

When the PCV valve is blocked to fresh air or a mixture of fresh air and "blow-by", less oxygen is taken into the combustion chamber, thereby increasing % of CO.

If hydrocarbon (HC) had increased while the PCV valve was open to fresh air, this may be a result of the carburetor setting too lean.

Too much oxygen does not allow for an adequate air-fuel mixture and may not combust properly. As a result, unburned fuel will be emitted from the tailpipe in the form of HC.

A small amount of "blow-by" is normal. However, the extent of change of % of CO is dependent on the amount of blow-by. Large changes in CO, when performing test, may give a clue to the condition of the piston rings.

CHECKING THE AIR INJECTOR

Some emission controlled systems use an air injection system which pumps fresh air into the exhaust manifold to complete an afterburning process of the exhaust gas.

Whether the pump system is referred to as thermactor, A.I.R. (Air Injection Reactor) or A.G. (Air Guard) or any other name, the principle is the same.

- Allow the engine to idle and observe the CO reading.
- Disconnect the air injector hose from the exhaust manifold and observe the CO reading.

There should be a noticeable increase in the % of CO.

Further diagnosis of engine emissions and malfunctions requires the removal of the air injector hose.

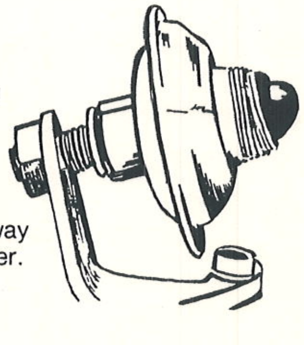
When testing is complete, be sure to reconnect the injector hose and all vacuum hoses, linkages, etc.

CHECKING THE DASHPOT

The purpose of the dashpot is to keep the engine from stalling at sudden deceleration.

At this time we are concerned only with the operation of the dashpot. After the carburetor adjustments and curb idle speeds have been set, then the dashpot is set.

- Hold the engine RPM at approximately 1500 RPM.
- Release the throttle and note a fast drop in engine RPM to approximately 100 RPM above idle, then a slow and gradual RPM drop to idle.



In order to avoid interference in the final RPM setting, loosen the locknut and back dashpot away from throttle lever.

CHECKING THE ACCELERATOR PUMP

When the throttle plate is quickly opened, the flow of air increases immediately, however, the fuel, being heavier than air, does not readily flow. This results in a momentarily lean mixture.

The accelerator pump assists the flow of fuel by discharging extra fuel into the venturi air stream by a plunger that is linked to the throttle lever.

The accelerator pump provides a momentary richer mixture which will increase the CO content and HC content in the emissions.

- Set the engine speed at fast idle and allow both the CO and HC to stabilize.
- Momentarily open and close the throttle without raising the engine speed.

OBSERVE BOTH THE CO AND HC READINGS

Up to a 1% increase in CO and a 600 PPM increase in HC is normal.

CHECKING THE POWER VALVE OPERATION

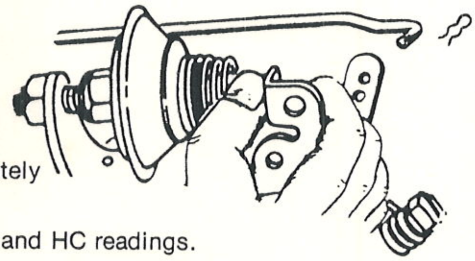
The power valve is needed to supplement the fuel supply at higher speeds since richer mixtures are needed for maximum engine power performance.

A quick verification of power valve operation can be accomplished by creating a momentary "near zero" vacuum.

The increased air flow will lift the power valve from its seat and supplement the fuel flow.

Not only is it important to verify the power valve opening, but equally important to verify whether the power valve reseats properly.

- Disconnect the accelerator pump linkage and stabilize the engine RPM at approximately 1500 RPM.



- Note the CO and HC readings.
- While holding the fast idle cam in one hand, quickly open and return the throttle to the fast idle opening.
- Observe the change in CO and HC reading.

It is important to return to the same fast idle cam setting in order to check for proper reseating of the power valve. This test may be repeated several times to check for consistency.

A momentary increase (1 - 2%) in CO and a return to the original CO reading should be expected.

A momentary increase in HC (100-200 PPM) and a return to the original reading should also be expected.

EXHAUST ANALYSIS (IDLE)

The purpose of this test is to check for consistency in performance of the carburetor as engine requirements change and then return to their original conditions.

The objective at this point is to obtain information about the carburetor and not to set the idle mixture.

- Allow the engine to idle and note the CO and HC readings.
- Raise the engine RPM to approximately 2000 RPM and hold momentarily.
- Release the throttle to idle and observe the CO and HC readings after they stabilize.

The ideal condition would be that both the CO and HC readings return to their original reading.

When the readings on the CO meter stabilize within .2% of the original reading . . . and the HC meter stabilizes within 20 PPM . . . the carburetor repeatability is acceptable.

However, when the carburetor cannot return the CO and HC readings within .4% or 40 PPM, the carburetor likely needs attention.

Look for binding throttle shaft, fast idle cam obstruction, dashpot or idle stop solenoid condition, etc.

Air bleed ports and fuel passage obstructions may also cause inconsistent CO and HC readings at idle.

It is recommended that this test be performed 2 or 3 times in order to obtain accurate test results.

EXHAUST ANALYSIS (CRUISE)

At higher engine speeds, (approximately 2000 RPM) the main metering circuit supplements the fuel supply due to an increased air flow through the venturi.

If the main metering system is not functioning correctly, the air-fuel mixture will "lean-out", possibly to a point of lean misfire.

The purpose of this test is to determine whether the main metering circuit supplements the fuel supply at cruising speeds.

Even though the main metering circuit maintains the proper air-fuel ratios at higher speeds, a noticeable drop in both CO and HC should be indicated due to increased combustion efficiency with higher engine combustion chamber temperatures.

PROCEDURE:

- Hold the engine speed steady at approximately 2000 RPM.
- Observe the CO and HC readings.

Compare these results with those of the previous idle emissions test.

There should be a reduction in both CO and HC up to 50% of the previous idle tests.

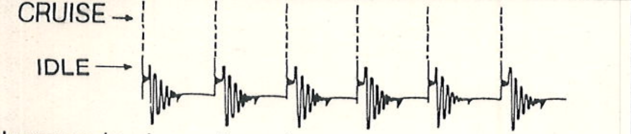
Increases in CO, while HC remains approximately the same or reduces slightly indicates a possible high float level setting or leaky valve seat.

At this time, too much fuel is entering the combustion chamber.

On the other hand, increases in HC while the CO significantly reduces is a strong indication that the main metering circuit is not supplementing the air-fuel mixture and an excessively lean mixture is entering the combustion chamber.

Verify the lean mixture by observing the secondary pattern display on your scope.

Increase in plug voltage demand and shorting of the spark duration will likely be noticed.



Increase in plug voltage demand, possible lean-misfire conditions contribute to increased HC emissions.

This condition can be the result of low float level setting or restrictions in the main metering jets or main well tubes.

CARBURETOR IDLE MIXTURE

Carburetor adjustments should be made in accordance with the automobile manufacturers specifications.

Generally this requires that the engine operating temperature has been reached and the air cleaner in place.

Setting the idle mixture by the "lean drop idle" method with the use of an accurate tachometer is generally an acceptable procedure.

Also, setting the idle mixture by the use of an infrared emissions analyzer is also an approved method.

Either method of adjustment should be accomplished within an idle time of 3 minutes or less.

If the idle mixture adjustment is not completed within 3 minutes, hold engine RPM at 2000 RPM for 1 minutes. This is to compensate for fuel and temperature variations.

"LEAN DROP IDLE"

- Carefully remove the limiter caps by installing a #10 sheet metal screw in the center of the cap and turning clockwise.
- Adjust the idle mixture screw(s) 1/8 turn at a time until the highest RPM is obtained.
- Lean the idle mixture adjustments for a drop in RPM specified by the manufacturer (generally 10 RPM per venturi).
- Reset curb idle speed.

INFRARED ANALYZER

- Adjust the curb idle speed to the manufacturers specifications. Refer to the underhood label.
- Observe the CO reading. If the CO is greater or less than the specified reading, reset the idle mixture adjustments.
- Turn the idle adjust screws 1/16 turn at a time until the specified CO is obtained.

If the engine speed changes more than 30 RPM while adjusting, reset the curb idle to manufacturers specifications and repeat the idle mixture adjustment until the specified CO is obtained.

If the specified CO is unable to be obtained at the correct idle speed, remove the limiter caps by inserting a #10 sheet metal screw in the center of the cap and rotate inward.

- Adjust to specified CO and RPM as above.

On automobiles with catalytic converters, the "Lean Drop Idle" method is recommended.

HYDROCARBON PER CYLINDER

Engine performance is directly related to how well the engine breathes and what the engine breathes.

For diagnostic purposes we can measure the breathing characteristics of each cylinder by not allowing the mixture to burn in that cylinder.

The method of "Killing" the cylinder is accomplished by the use of the scope analyzer and selecting the individual cylinders one at a time.

PROCEDURE:

- Set the engine speed at approximately 1500 RPM.
- Depress the cylinder KILL pushbutton and the desired cylinder pushbutton to prevent the fuel in that combustion chamber from burning.

The fuel that was not burned will be emitted at the tailpipe.

What the engine requires is the INTAKE of fuel, COMPRESSION of fuel, TIMED IGNITION, and COMBUSTION of the fuel. If any of these are missing or wrong, engine performance will suffer.

The chart below shows some possible test results and probable causes.

1. Every other cylinder reads higher than the average.	Unbalanced carburetor, carburetor base or manifold air leak.
2. Two cylinders on the same intake runner	Vacuum leak, check for hoses off, intake manifold leak.
3. One or two cylinders low	Sticky or poorly seated valve, intake manifold restriction . . . intake manifold restriction will likely be true at higher RPM as well, while a sticky valve may show more normal at high RPM.
4. All cylinders reading equal but cylinder balance reading low on some cylinders.	Not related to fuel, check scope for ignition if OK, check compression

CATALYTIC CONVERTERS

Individual or multiple cylinder "kill" testing and measuring the hydrocarbon output is an acceptable procedure. The specific cylinder should not be "killed" for more than 10 seconds at one time and allow a few seconds between cylinder "kills" to allow the converter to restore its full operating capacity.

A slight increase in hydrocarbon content should be expected with each cylinder that is "killed" (approximately 200-400 PPM). A noticeable, but little increase in CO may be seen.

EFI (ELECTRONIC FUEL INJECTION)

The electronic fuel injection (EFI) provides a means of previsely controlling the air-fuel mixture as engine demands change.

Most EFI systems are controlled by an electronic computer module which monitors selected engine conditions and generates a voltage pulse to the injector solenoids at the proper time and for the proper duration.

Fuel is supplied to the inlet of the injectors at a high enough pressure to provide good fuel atomization. As the engine demand calls for more fuel, the quantity is changed by lengthening the time the injectors are opened.

The injector valves are generally mounted in the intake manifold with their outlets directed towards the intake valve. This method is commonly known as port injection.

The EFI system where all of the injector valves are opened at the same time is called continuous or simultaneous injection.

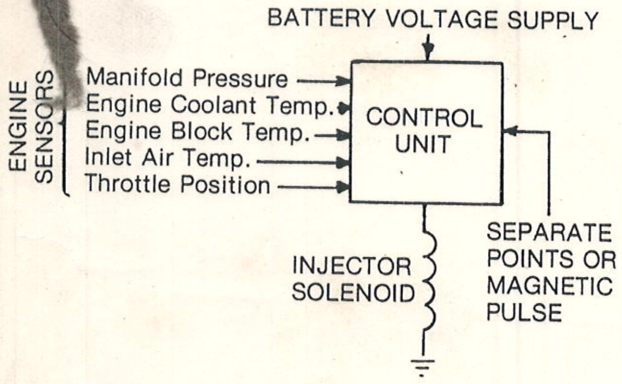
When only 1/2 of the injector valves open at one time and the other 1/2 open at another time, the method is referred to as group injection.

Basically there are two types of EFI control systems, the MPC (Manifold Pressure Control) and the AFC (Air Flow Control).

MPC SYSTEM

With this system the injector solenoids are in the ground circuit of the electronic computer module. When the module is instructed to fire, the injectors by a separate set of points or magnetic pulse, the injector solenoids receive a positive pulse.

FIGURE 1



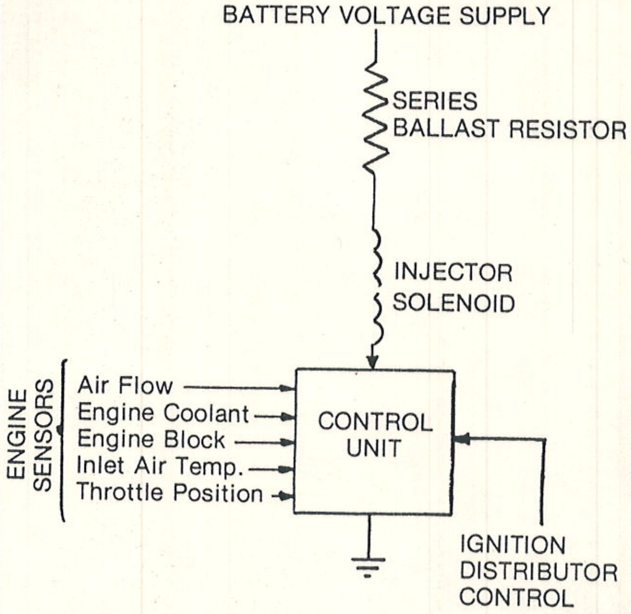
The various engine sensors send information to the computer control module which is used to calculate the length of injection time.

AFC SYSTEM

With this system the injector solenoids are in the power circuit of the computer module.

When the module is instructed to fire the injectors by the ignition system, the module grounds the injector solenoid.

FIGURE 2



Either system of control fires the injectors twice with each revolution of the distributor.

FIGURE 3

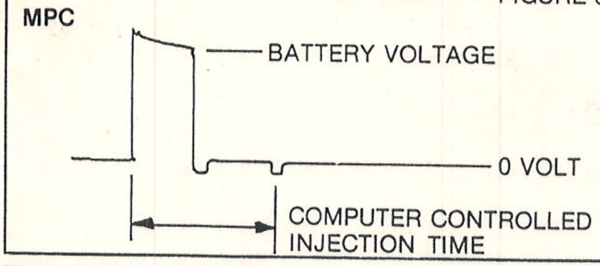
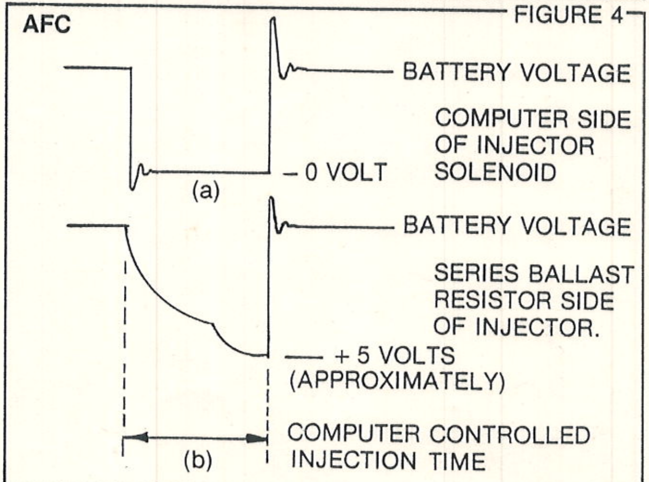


FIGURE 4



The waveforms above represent the pulses to the injector solenoids. Analysis of the EFI systems is to measure the computer response to engine condition changes with respect to time.

AFC SYSTEM CHECK

- Leave the engine harness connected to the ignition system as normal.

  OR . . .

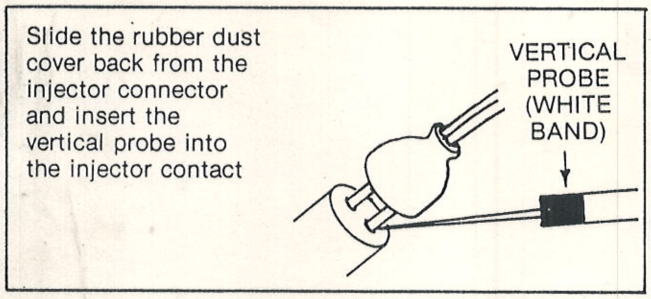
Connect the black lead to engine ground. Connect the green lead to Dist. (—) coil. Connect the #1 pick-up to the #1 spark plug wire.

- Select the LO VOLT/ SPECIAL TEST pushbutton and the 5MS pushbutton in the sweep selector.

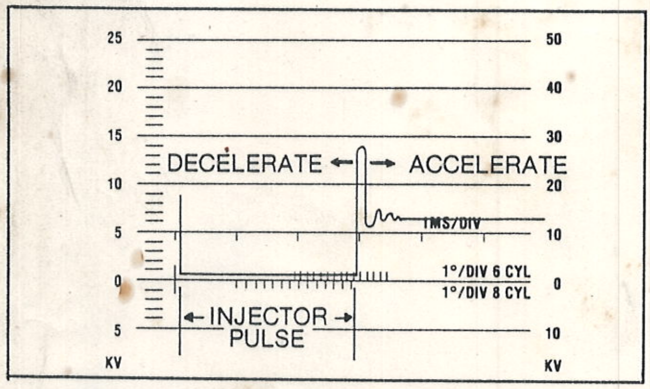
LO VOLT SPEC ☐

5MS ☐

Use the VERTICAL PROBE to measure the injector solenoid (any injector).


Slide the rubber dust cover back from the injector connector and insert the vertical probe into the injector contact

- Select the SUPERIMPOSED pushbutton on the pattern selector.



- Accelerate the engine and notice the right edge of the injector pulse.

The more rapid the acceleration the further the injector pulse will move to the right.

- Hold the engine RPM and allow the injector pulse width to stabilize.
- Release the throttle and observe the right edge of the injector pulse.

It should move to the left while the engine RPM decreases, then lengthen to its normal position (Approximately 3-3.5 MS).

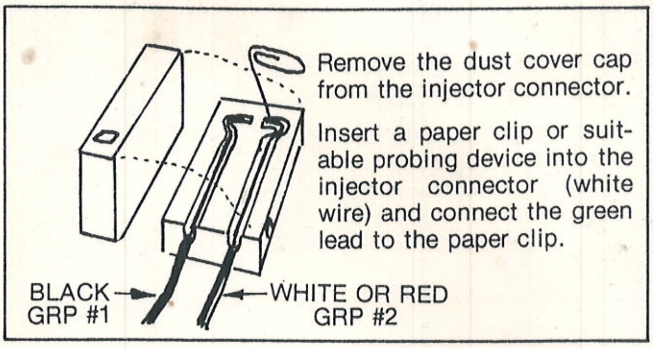
Essentially this provides an indication that the electronic computer is responding to the changing engine conditions and correcting the injector time accordingly.

If the computer and sensors are working, malfunctioning injectors can be determined by emission analysis.

Measuring the hydrocarbon per cylinder as described on page 29 will provide us with information regarding open or clogged injectors.

MPC SYSTEM CHECK

- Connect the green lead to the injector terminal.


Remove the dust cover cap from the injector connector.

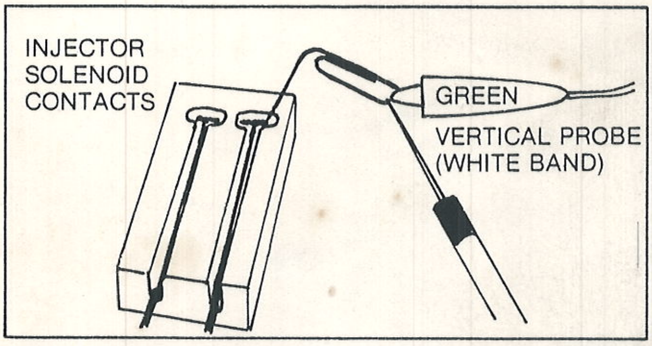
Insert a paper clip or suitable probing device into the injector connector (white wire) and connect the green lead to the paper clip.

Select the LO VOLT/ SPECIAL TEST pushbutton and the 5MS pushbutton in the sweep selector.

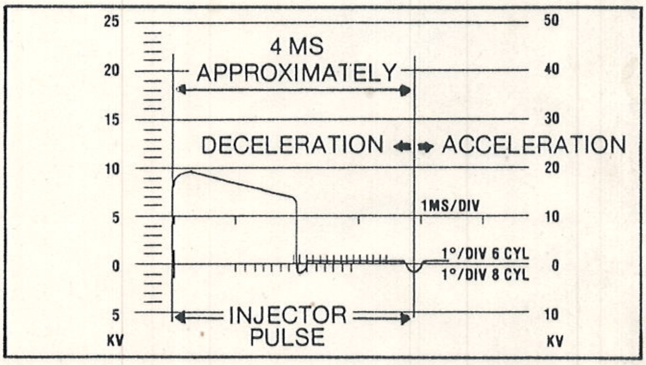
LO VOLT/ SPEC ☐

5MS ☐

Use the VERTICAL PROBE to measure the injector solenoid at the same point as the green lead.



- Select the SUPERIMPOSED pushbutton in the pattern selector.



- Accelerate the engine and notice the right edge of the injector pulse. The more rapid the acceleration the further the injector pulse will move to the right.